

Draft

An Independent, Scientific Review of the Biological Opinion (2010)
of the Fisheries Management Plan
for the Bering Sea/Aleutian Islands Management Plan

Review Panel: Dr. David R. Bernard (co-chair)
Mr. Steven J. Jeffries (co-chair)
Dr. Gunnar Knapp
Dr. Andrew W. Trites

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Anchorage, AK USA
Lakewood, WA USA
Vancouver, BC Canada

PROLOUGE

During the development of the recent Biological Opinion by the National Marine Fisheries Service concerning the impact of groundfish fisheries in the Bering Sea, Aleutian Islands and Gulf of Alaska on Steller sea lions, the lack of consensus among the scientific community concerning the causes for decline was obvious. Consequently, many fishery managers, resource scientists, and industry stakeholders expressed concern about the credibility of the Biological Opinion, and about the impact of conflicting scientific theories on the scientific foundations for ecosystem-based management of North Pacific fisheries. The Alaska Department of Fish and Game (ADFG) and the Washington Department of Fish and Wildlife (WDFW) share many of these concerns, and as a result, agreed to jointly convene an independent panel to scientifically review the Biological Opinion, and provide their findings and recommendations in a timely manner to the public.

In April 2011, ADFG and WDFW developed the initial terms of reference for the review and selected two panel co-chairs for this effort. The co-chairs selected two additional panel members, and developed the final terms of reference, timeline for their work, and format of the draft report. The terms of reference and biographies of the panel members are posted on the web at:

http://wdfw.wa.gov/conservation/steller_sealions/.

Following selection of the co-chairs, the role of ADFG and WDFW was limited to providing administrative and financial support; the panel has worked completely independently to produce this draft report.

We greatly appreciate the efforts of the panel members in assimilating a large amount of information, weighing many conflicting theories in a relatively short amount of time, and providing the region with this draft of their review and recommendations. Now, the science process becomes a dialogue, and we have the opportunity to provide the panel with our feedback on their efforts. They will receive our input at a public meeting in Anchorage, to be held later in August, as well as electronic comments submitted through the WDFW website address listed above. Neither ADFG nor WDFW have seen any of their work to date; we will be reviewing and commenting along with others in the region. Consequently, this document containing the panel's draft review and recommendations does not reflect the official views or positions of ADFG, WDFW, or the parent organizations of any of the panel members.

Draft Scientific Review of the Biological Opinion (2010)

We hope that the efforts of the review panel will assist the region in determining the strength and validity of the science that underlies our efforts to manage the fishery in an ecosystem context, for all trophic levels including top level predators such as Steller Sea Lions and commercial fisheries. If the panel's efforts help to resolve some of the apparent scientific conflicts, that will be of great value. But, if those conflicts cannot be resolved yet, we hope that the work of the panel members will be of assistance in clarifying the strengths and weaknesses of the existing science, and areas where further research and understanding will help to provide future resolution.

– Bill Tweit
– Douglas Vincent-Lang

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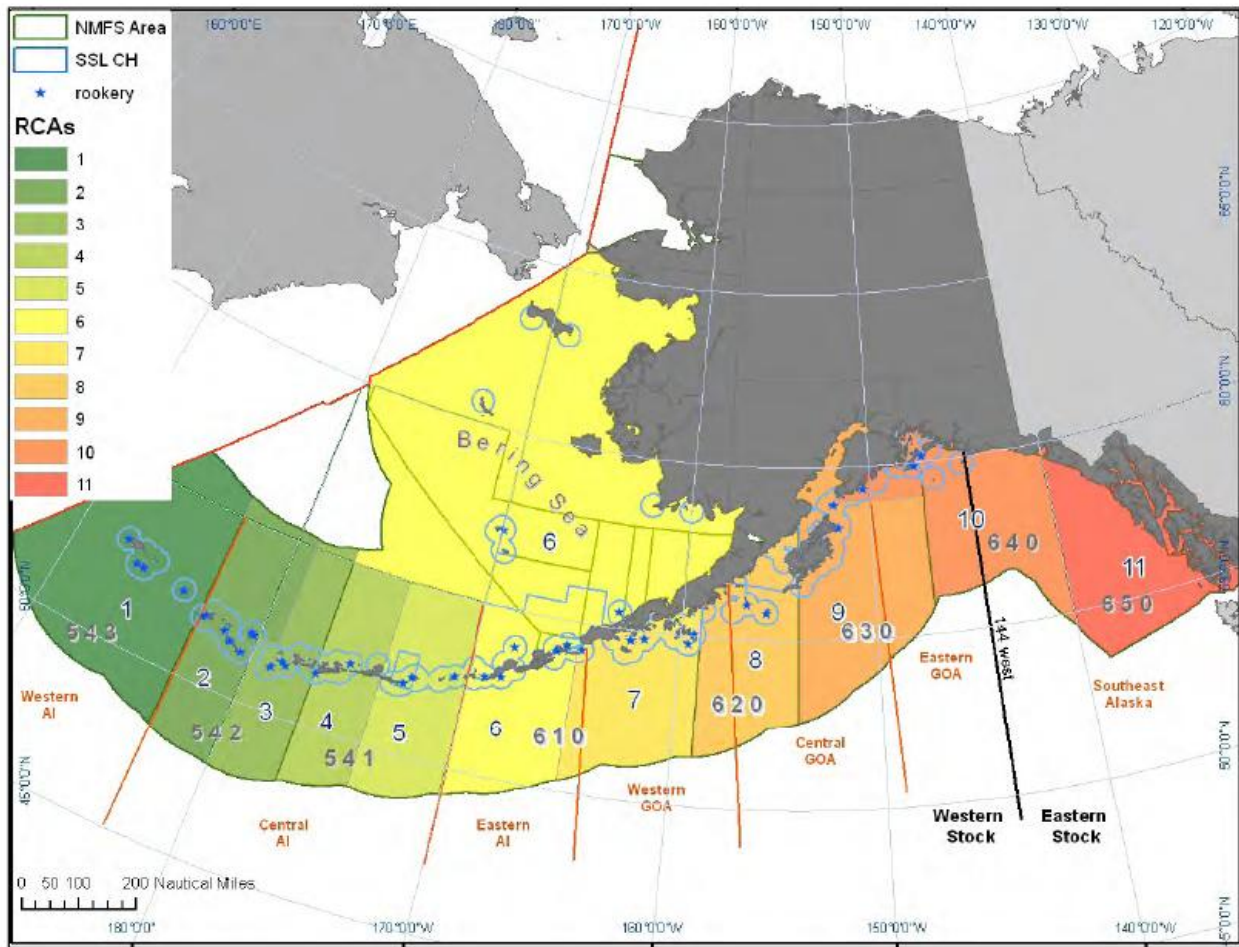
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EXECUTIVE SUMMARY

This is a draft report for public comment on an independent scientific review of the Biological Opinion (BiOp) issued 24 November, 2010 by the National Marine Fisheries Service (NMFS) of the Fisheries Management Plan (FMP) for the Bering Sea and Aleutian Islands (BSAI) Management Area (NMFS 2010a) under a section 7 consultation required by the Endangered Species Act. The four-member review panel consisted of two marine mammal scientists, one fisheries scientist, and one resource economist. Two panel members had no previous knowledge of Steller sea lion research, and three members had not read the BiOp prior to this review. The review was to concentrate on issues involving the western distinct population segment (WDPS) of Steller sea lions in general, and on sea lions and fisheries in the western and central Aleutian Islands in detail (see map in frontispiece).

We were charged as a review panel to answer a series of questions concerning the BiOp and its central conclusion of jeopardy:

“After reviewing the current status of critical habitat that has been designated for the western population of Steller sea lions, the environmental baseline for the action area, the proposed action for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS’ biological opinion that the action, as proposed, is likely to adversely modify the designated critical habitat for the western DPS of Steller sea lion.” [BiOp, xxxiv]

We answered each of the specific questions in our terms of reference (see Chapter 9). For this Executive Summary, however, we have grouped our findings into four categories pertaining to:

- the finding of jeopardy of adverse modification (JAM) of habitat for groundfish fisheries in the western and central Aleutian Islands;
- the effectiveness of reasonable and prudent alternatives (RPAs) to the federal action under consultation;
- the requirement under the Environmental Protection Act (EPA) that RPAs in the BiOp be the least-cost choice from all efficacious RPAs; and
- consideration of public and peer comment in the writing of the BiOp.

In our review, we looked for consistencies and inconsistencies between data and conclusions in the BiOp based on our experience, knowledge of the relevant scientific literature, and relevant public comments. Besides information referenced in the BiOp, we considered recently published scientific papers, recent stock assessments, and recent groundfish surveys. We also considered comments by industry, scientists, and the North Pacific Management Council through their Science and Statistical Committee concerning the BiOp in general and specific modifications to RPAs, as well as comments submitted to us at a public hearing held June 2, 2011 in Seattle and by e-mail.

On now to the summary of our review.

The Finding of Jeopardy

We do not agree with the finding of JAM (jeopardy of adverse modification) for Steller sea lions in the western and central Aleutian Islands as concluded in the BiOp for the FMP. We find that NMFS misinterpreted crucial evidence from statistical studies of relationships between fishing and sea lion demographics. NMFS also failed to scientifically support their explanation of how fisheries affected sea lions (fishery-driven nutritional stress), and disregarded or misreported evidence that refutes the fishery-driven nutritional stress hypothesis. And finally, NMFS did not seriously consider alternative ecologically mediated explanations for declines in sea lion numbers not involving fisheries (environmentally-driven nutritional stress and the killer whale predation hypotheses).

Statistical analyses are the starting point for examining the relationship between fishing and Steller sea lions. If fisheries adversely affect sea lion numbers, statistically significant negative associations should be detectable between measures of fishing and measures of sea lion numbers. Failing to find any such associations should lead to a conclusion that there is no adverse effect unless there are clear reasons why the effects would not be observable in the data (*e.g.* measurement error, insufficient variation, or low power). Eight studies looking for such statistical associations were cited in the BiOp. NMFS concluded results from these studies to be “equivocal” and that “*it is not possible ... to conclude that commercial fisheries are not having a significant impact on the recovery of [sea lions]*”. We found these studies insightful and their results hardly “equivocal”.

We undertook a meta-analysis of the eight statistical studies cited in the BiOp plus two additional studies. The tests in earlier studies were based on a few years of data, and as expected, the subsequent low power produced mostly non-significant outcomes with a few negative and a few positive associations being statistically significant. These results can be considered equivocal. Studies published after 2000 involved more years and consequently had more power to detect an association between fisheries and Steller sea lions. Results from these studies for years prior to 2000 were less equivocal in that 40% of tests produced statistically significant associations that were consistent with fisheries *having* had a negative impact on sea Steller sea lions; the remaining tests (60%) had statistically non-significant outcomes which is consistent with fisheries *not* having had a negative impact on sea lions. All of the detected associations were weak. However, results for years after 2000 are unequivocal. *None of these studies found statistically significant associations consistent with harm by fisheries, that is, 100% of the tests resulted in outcomes consistent with the groundfish fisheries having had no effect on sea lion numbers in the last 10-20 years.* Power analyses in these latter studies and the results themselves show that even weak negative associations would have been detected had they been present. The methodological issues brought forward through comments to the draft BiOp concern statistical significance in tests when significance is not warranted. None of the issues would make a negative association less likely to be detected.

For a specific scientific hypothesis that fisheries negatively impact sea lion numbers, significant negative associations between fishery and sea lion statistics are evidence that this hypothesis is *possibly true*. Non-significant and statistically significant positive associations are evidence this hypothesis is *probably false*. What the meta-analysis provides is evidence that a hypothesis that

fisheries have a negative impact on Steller sea lions of the WDPS in general, and specifically on sea lions in the western and central Aleutian Islands, was *possibly true* in the past, but in the last 10-20 years the hypothesis is *probably false*. On this basis we find that not only is it possible “that commercial fisheries are not having a significant impact on the recovery of [sea lions]”, but the proposition is highly likely.

In our judgment, the fishery-driven nutritional stress hypothesis proffered by NMFS as an explanation for population declines in the western and central Aleutian Islands should be scientifically rejected. We base our conclusion on the process and conditions specified in the decision trees given in the BiOp for determining the risk of exposure and subsequent nutritional stress [BiOp; Figures 4.24, 4.25]. The BiOp drew some incorrect conclusions as it navigated through its own decision tree to arrive at the finding Atka mackerel and Pacific cod fisheries were fisheries of concern. The BiOp also ignored evidence contradicting the hypothesis of fishery-driven nutritional stress.

The available data and analyses indicate that current harvest rates of Atka mackerel have been too low, and the population of Pacific cod has been too small for the fishery on either species to cause nutritional stress in sea lions. Modeling efforts by NMFS and reported in the BiOp support this observation, especially the lack of an effect of the Pacific cod fishery on sea lion biomass. Attempts in the BiOp to show spatial overlap between catches in fisheries and diets of sea lions, and hence local depletion of prey, failed to convincingly do so. Uncertainty in estimates of forage biomass is large and was ignored in the BiOp. Other measures of possible competition between fisheries and sea lions (*e.g.*, size overlap, temporal overlap, depth overlap) were specified in the BiOp, but not investigated.

Arguments presented in the BiOp that sea lions are experiencing nutritional stress caused by a lack of groundfish are not convincing. Forage ratios of groundfish to sea lions were higher in the western and central Aleutians than in regions where sea lions are recovering, thereby indicating a quantity of groundfish area-wide sufficient for sea lions to avoid nutritional stress. Sea lions in the eastern Bering Sea and the Gulf of Alaska (GOA) show no signs of nutritional stress despite having forage ratios within critical habitat that are lower than in the western and central Aleutian Islands.

Direct evidence of sea lions being in nutritional stress is lacking in the BiOp. We compared the signs of fishery-driven nutritional stress listed in Figure 4.26 of the BiOp with data provided in Table 3.17 of the BiOp. Of the eight general conditions consistent with fishery-driven nutritional stress in sea lions, no recent information (after 2000) was available on four. Nutritional stress was not indicated for three conditions (sea lions were not emaciated, body size was not reduced, and survival was not reduced). Information on the final general condition (reduced reproduction) was contradictory.

Considering the compelling evidence that the amounts of prey are sufficient to support sea lions in the western and central Aleutian Islands specifically, and for the western population in general, it should not be surprising that direct evidence for fishery-driven nutritional stress could not be found as posited. Making two “yes” decisions at the only two operable decision points of the decision process laid out in Figure 4.25 of the BiOp should have ended in a decision of “No

Nutritional Stress”. Such a decision would have been consistent with the results of the meta-analysis on statistical studies described above.

Of the two leading alternate hypotheses to explain the reduced numbers of Steller sea lions in the western and central Aleutian Islands, we conclude that neither the hypotheses of environmentally-driven nutritional stress (the “*junk food*” hypothesis) or killer whale predation can be scientifically rejected with available data. Both hypotheses remain viable explanations of sea lion demographics. Of the five necessary conditions for acceptance of the “*junk food*” hypothesis, there is evidence supporting two: good pup condition and low pup to non-pup ratios (a proxy for birth rates) in the western and central Aleutian Islands. There is no information on the other three necessary conditions (good adult body condition, short foraging trips, and older age at weaning for pups).

While the BiOp contained no conclusion as to rejecting or not rejecting the “*junk food*” hypothesis, the BiOp did state “*killer whale predation can be an important factor in either causing continued declines or contributing to a robust recovery [of sea lions].*” We interpret this statement as implying that the killer whale predation hypothesis cannot be rejected at this time. We concur.

Effectiveness of RPAs

Based on the evidence presented in the BiOp, we conclude that the proposed RPAs will not arrest the decline in the numbers of sea lions in the western and central Aleutian Islands. Evidence presented in this BiOp from multispecies modeling indicates that any future increase or stabilization in sea lion biomass in the western and central Aleutian Islands will *not* be due to restricting fisheries for Pacific cod. There is some modeling evidence in the BiOp indicating that halting fishing for Atka mackerel in the western and central Aleutian Islands might cause sea lion biomass to increase, but it is inconsistent with the data on forage ratios showing greater declines of sea lions are associated with greater relative biomasses of groundfish. The BiOp does not consider this possibility—that increased amounts of groundfish might have negative consequences to sea lions as postulated by the “*junk food*” hypothesis.

Aydin (2010) predicted a 6% increase in sea lion biomass with a 10% percentage point reduction in the mortality rate for Atka mackerel. His model assumed that sea lions can assimilate the increase in Atka mackerel biomass, but did not consider that young sea lions can become full on low-energy diets before they have attained enough energy to meet their daily needs (see Rosen and Trites 2004).

The virtual 10 percentage point reduction in Atka mortality projected by Aydin (2010) represents closure of the fishery (which harvests 8% of the stock) plus an additional two percentage point reduction in the mortality rate for this species. Unfortunately certain critical bits of information relative to evaluating this finding were not in the BiOp. Most notably, the BiOp does not explain or discuss:

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- how could mortality rates on Atka mackerel be reduced further beyond the closure of the virtual fishery;
- how many years were needed to realize virtual increases in sea lion biomass;
- whether these virtual increases persist; and
- what the virtual effect of closing cod and mackerel fisheries would be on sea lion biomass?

Without such information, the relevance of these simulations involving closing the Atka mackerel fishery cannot be fully evaluated. However, this full evaluation would probably be of marginal value, considering the lack of evidence for the fishery-driven nutritional stress hypothesis (Chapter 4) and the meta-analysis of statistical studies described in Chapter 3 showing no negative effects of fishing for Atka mackerel in the western and central Aleutian Islands on sea lion demographics in the last 20 years.

Results from multispecies models can provide insights into the effectiveness of RPAs even though the models used in the BiOp were not well explained. The food web containing fish, fisheries, and sea lions must be modeled as a whole if the best ecological information (scientific data) is to be used. While such modeling is at the edge of current understanding of the ecosystem in the Aleutian Islands, such modeling directly addresses the objective of the consultation, which is the response of sea lions to implementation of the RPAs.

In the BiOp, NMFS appears to have eschewed multispecies modeling in favor of the simple dictum that “what worked there and then, will work here and now”—with the “there” being the Gulf of Alaska, the “then” being when RPAs from two previous BiOps were implemented, and the “here” being the western and central Aleutians. Such a simple approach is empirical in that it depends on personal experience and belief, and does not use the scientific method. In other words, the expectation that the RPAs will result in increased numbers of Steller sea lions was not determined using science.

Sea lion numbers in the Gulf of Alaska (GOA) increased following implementation of RPAs in the 1990s. However, no evidence was given in the BiOp that this increase in sea lions was other than coincidental with management actions. Evidence in the BiOp from multispecies modeling for the GOA indicate that the increase in sea lion numbers was a coincidence in the last decade and was not due to fishery restrictions. While NMFS did use single-species modeling of prey species to show the effectiveness of proposed RPAs—their results were preordained by the model they chose. Thus the models do not support the unscientific premise of the BiOp that RPAs had worked in the past, and would therefore continue to be effective if implemented elsewhere. There is insufficient evidence that past RPAs were ever effective.

The reason given in the BiOp for forgoing a scientific investigation in favor of an unscientific argument is that multi-species modeling is too complex and subject to too much error. We disagree. By its very nature, the fishery-driven nutritional stress hypothesis requires consideration of the fishery and sea lion food webs. Ecosystem considerations and modeling of the food web is a must for developing RPAs if the BiOp accepts the fishery-driven nutritional stress hypothesis. Such modeling is complex and does have uncertainty in outcomes. However, a good scientific investigation would include measures of uncertainty in parameters, in initial

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conditions, and in environmental conditions; would include an analysis of the sensitivity of results to model structure; and would report results in probabilistic terms.

We believe that NMFS has the resources to conduct ecosystem modeling, yet relied on the simplest of arguments to support the RPAs they proposed. Arguing that sea lions must be nutritionally stressed because fishing has occurred where sea lions have declined is prone to error in the most obvious of ways by confusing cause with coincidence.

Economic Analysis of RPAs

In general, the analysis described in the Environmental Assessment and Regulatory Impact Review (EA/RIR) of economic impacts of the chosen set of RPAs is reasonably complete, scientifically valid and adequate. It addresses most of the questions it should address objectively and reasonably, given the limits of available data and confidentiality restrictions. It supports the conclusion that “...*this action will impose relatively heavy costs on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands.*” More detailed analysis might have strengthened but would not have changed this fundamental conclusion.

The EA/RIR includes an analysis of the economic benefits of full Steller sea lion recovery. This is not an analysis of the economic benefits attributable to the uncertain effects of the alternatives. The EA/RIR does not provide a cost-benefit analysis of the alternatives.

The BiOp and RIR failed to demonstrate that the RPAs minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for Steller sea lion recovery. Neither document could demonstrate this because neither demonstrated what the benefits of the RPAs would be for sea lion recovery, or demonstrated an effort to identify alternatives that would have the same level of benefit but lower economic and social impact.

Standard for Likelihood of Jeopardy

The BiOp responds to the mandate in the ESA that:

“Each Federal agency shall . . . ensure that any action . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat...” [BiOp, 327]

In reaching or evaluating any conclusion about jeopardy, a key issue is the standard for “likely.” The lower the standard, the easier it is to meet.

The BiOp never defined the meaning of “likely” or indicated what standards it used to determine “likely”. Reading of the BiOp, however, suggests the BiOp applied an implicit standard of “possible” in drawing its most important conclusions, and in some instances used a standard of “not impossible.”

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The normal scientific standard for “likely” is “probable” or “most likely.” Qualifying conclusions in the BiOp using terms such as “*may*” and “*the possibility cannot be excluded*” indicates that the BiOp based its conclusion of jeopardy on a lower standard than the normal scientific meaning of “likely” or the standard we were directed to use by our review.

The appropriate definition for “likely” in reaching a conclusion of jeopardy is a critical issue faced by society in making the difficult choices of how to protect endangered species. We claim no expertise as to where society should set the standard of scientific likelihood for taking actions which impose costs on some groups for uncertain benefits for the survival or recovery of a species. However, whatever the standard, decisions should be based on the best possible understanding of the available scientific evidence.

Peer and Public Comment

The BiOp was prepared by NMFS without active interaction with scientists outside the agency or with people in the fishing industry that could have provided useful insights. The period of time provided by NMFS for comment on the draft BiOp was insufficient for serious peer and public review. The period of time between the receipt of review comments and NMFS’s self-imposed deadline for release of the final document was also insufficient for adequate consideration of review comments or any substantial revision of the BiOp in response to comments. There is little evidence that comments on the draft BiOp’s finding of jeopardy were seriously considered when developing the final BiOp. There is evidence that comments on RPAs in the draft BiOp were considered in developing the final RPAs, although responses to these comments were very brief and most suggested changes were rejected. NMFS did not summarize or address comments received on the draft BiOp as had been promised, nor has it scheduled a formal independent review as promised. In contrast, the RIR clearly addressed and was strengthened by consideration of public and peer comments on the economic analysis.

* * * *

We welcome receiving comments on this draft report by e-mail at:

StellerSeaLionComments@dfw.wa.gov,

and will hold a public hearing on this draft report in Anchorage, Alaska on 22 August, 2011. Details about the meeting will be posted at:

http://wdfw.wa.gov/conservation/steller_sealions/.

1. INTRODUCTION

This document is a draft of an independent scientific review of the biological opinion (BiOp) issued 24 November, 2010 of the Fisheries Management Plan (FMP) for the Bering Sea and Aleutian Islands (BSAI) management area (NMFS 2010a) under a section 7 consultation required by the Endangered Species Act. A final version of the review will be prepared following receipt of comments on this draft.

Background of the Review

Following the release of the draft BiOp in August 2010 and the final BiOp in October 2010, many concerns were expressed about the science in the draft BiOp. For example, the North Pacific Fishery Management Council unanimously passed a motion at its August 2010 meeting which included the following:

The Council notes concerns and recommendations for the analysis by their Science and Statistical Committee (SSC) including:

- *stating as fact some conclusions that still have a great deal of uncertainty about them such as past conservation methods having a “positive impact on reducing the impacts of the fishery exploitation strategy on Steller sea lions”;*
- *assumptions underlying the BiOp analysis including biomass projection methodology, biomass apportionment, and nutritional stress as the causal factor for low natality;*
- *the global scale of the RPA relative to the current information base and conservation goal; and*
- *questions raised in the editorial comments of the SSC*

and therefore recommends an independent review of the BiOp.

In response to these concerns, the States of Alaska and Washington jointly funded this review. Appendix A provides the full terms of references for the review.

Review Panel

The review panel was selected according to the following process outlined in the Terms of Reference:

The panel will consist of two co-chairs, one selected by the Alaska Department of Fish and Game (ADFG) and the other by the Washington Department of Fish and Wildlife (WDFW). The co-chairs will select two other members. All four will be experienced scientists in one or more fields of fisheries management, animal population dynamics, marine mammal biology, and resource economics. None of

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the four will be federal employees, or have any direct connection with development of this BiOp.

The panel members are:

- Dr. David Bernard (co-chair), a fisheries scientist and biometrician with over 30 years post-graduate experience involving management of commercial and recreational fisheries for salmon and non-salmon species in the Pacific Northwest.
- Mr. Steven Jeffries (co-chair), a Research Scientist and marine mammal specialist for the Washington Department of Fish and Wildlife, with more than 30 years of experience working on a variety of Northwest marine mammal issues.
- Dr. Andrew Trites, Professor and Director of the Marine Mammal Research Unit in the Fisheries Centre at the University of British Columbia, who has conducted extensive research on the ecology, population biology and bioenergetics of seals, sea lions and whales.
- Dr. Gunnar Knapp, Professor of Economics at the University of Alaska Anchorage Institute of Social and Economic Research, who has been engaged in research on fisheries management, seafood markets, and the Alaska economy for the past 30 years.

Appendix B provides more detailed biographies for panel members.

This is an independent review. The conclusions expressed are our own and (as directed by the Terms of Reference) represent our consensus. None of us are federal employees. None of us had any role in developing the BiOp or the FMP. None of us have any personal or financial involvement in any fisheries involved in the BiOp.

We bring a variety of backgrounds and perspectives to our review. One member of the panel (Dr. Trites) has an extensive background in Steller sea lion research, is widely cited in the BiOp, and commented on the draft BiOp and final BiOp. One member (Mr. Jeffries) has extensive experience in sea lion research, marine mammal fishery interactions, and is a member of the Pacific Scientific Review Group. Two members of the panel (Dr. Bernard and Dr. Knapp) have no previous background in or knowledge of Steller sea lion research. Three members of the panel (Dr. Bernard, Mr. Jeffries and Dr. Knapp) had never seen the BiOp prior to beginning work on this review.

Various parties are now involved in litigation relating to the BiOp. This review has no relationship to that litigation, and we express no opinions about the litigation in this review, or about any legal questions related to the BiOp or the EA/RIR (Environmental Assessment/Regulatory Impact Review). Our focus is strictly on the scientific questions in our Terms of Reference.

Organization of the Review

The scientific charge to the panel is summarized on the following page. Our focus throughout was on answering questions posed in the Terms of Reference (Chapter 9) through attention to the most important scientific issues in the BiOp (Chapters 3-6) and economic issues in the EA/RIR (Chapter 7). We also reviewed the process used to solicit and incorporate comments from scientists and from the public into the BiOp and EA/RIR (Chapter 8); as well as commented on standards in the BiOp for deciding jeopardy compared to common scientific standards (Chapter 2).

Quotations/Figures/Tables from the BiOp

In our review, we quote extensively from the BiOp and other references. All extended quotations are given in indented italic text, with citations to the reference and page number following the quotations in brackets. Figures and tables in the BiOp reproduced whole or in part in our review are referenced in similar manner. For simplicity, we refer hereafter to the Final Biological Opinion as “BiOp” and to the final Environmental Assessment/Regulatory Impact Review as “EA/RIR”. Sections of quoted text from the BiOp which we wish to emphasize are underlined. All such underlining should be considered “emphasis added.” We emphasize our own text with italics without quotes. Quotes in the text without italics denote what we consider a special phrase.

Scientific Charge to the Review Panel (from the Terms of Reference)

The panel will focus, but not necessarily limit, their review on the conclusions in the BiOp regarding the Western Distinct Population Segment (WDPS) of Steller sea lions (SSL). The panel will judge and report on how well the BiOp met the following:

- Do the conclusions in the BiOp regarding the finding of jeopardy and its posited cause (nutritional stress from food competition with fisheries) follow logically from scientific, economic, and social information presented in the BiOp and attendant documents?
- Are the conclusions contradicted by any scientific, economic, and social information not presented in the BiOp?
- Do the conclusions represent the most likely scientific explanation for apparent population dynamics of the WDPS of SSL given the current state of knowledge?
- Were alternative scientific explanations to the apparent population dynamics of the WDPS of SSL thoroughly considered, such as explanations involving but not limited to predation, disease, ecosystem/carrying capacity, or emigration?
- Do the Reasonable and Prudent Actions (RPA) imposed on the fishery follow logically from the conclusions regarding jeopardy?
- Are the RPA's sufficient to mitigate jeopardy, and are they likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for SSL recovery?
- Are the RPAs likely to effectively meet recovery goals for the WDPS of SSL?
- Is the scientific record reported in the BiOp reasonably complete?
- Is there evidence that the relevant peer and public comments concerning economic and scientific issues were considered when developing the BiOp—including comments on the draft BiOp?

The panel will use their experience, knowledge of the relevant scientific literature, and relevant public comments in their judgments. Knowledge will include, but will not be limited to, recently published scientific papers, recent stock assessments, and recent population surveys. Relevant public comments will include, but will not be limited to, comments submitted by industry, scientists and the North Pacific Management Council through their Science and Statistical Committee concerning the BiOp in general and concerning specific modifications to RPAs. During their deliberations the panel will note any potential investigations that could likely provide new information critical to eliminating or possibly confirming a scientific explanation of the apparent slow recovery of the WDPS of SSL.

2. THE BIOP'S STANDARD FOR LIKLIHOOD OF JEOPARDY

The BiOp responds to the mandate in the ESA that:


“Each Federal agency shall, in consultation with and with the assistance of the Secretary, ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat...” [BiOp, 327]

In reaching or evaluating any conclusion about jeopardy, a key issue is the standard for “likely.” What kind of scientific evidence is required to conclude an outcome is “likely” or “not likely”? The answer to this question is by no means obvious. As noted in public testimony to the North Pacific Fishery Management Council at its August 2010 meeting:

“Likely is not a black and white kind of term. It’s a lonely word that craves for the company of an adverb such as ‘perhaps.’ Fairly likely, sort of likely, not so likely, highly likely. But it’s not an absolute kind of term.” [Mr. Dave Fraser, 2010_8_19_303.mp3, 9:07]

There is a wide range of potential standards for “likely,” corresponding to different standards of scientific evidence. These include, for example, “highly likely,” “probable,” “most likely,” “possible,” and “not impossible” (Table 2.1).

Table 2.1.—Examples of potential standards of scientific evidence for “likely”.

Standard	Standard of Scientific Evidence	Probability of actual jeopardy, based on the available evidence
True	Proved with 100% certainty	100%
Highly likely	All or almost all scientific evidence supports the conclusion	
Probable	The weight of scientific evidence supports the conclusion; relatively little evidence supports other conclusions or is inconclusive	
Most likely	More scientific evidence supports the conclusion than other potential conclusions, but much of the evidence is inconclusive	
Possible	Some scientific evidence supports the conclusion, but the weight of the evidence supports other potential conclusions or is inconclusive	
Not impossible	Very little scientific evidence supports the conclusion, but the possibility cannot be ruled out	
False	Disproved with 100% certainty	0%

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The definition of the standard for “likely” is critical for a scientific review of the conclusion of jeopardy. The lower the standard, the easier it is to meet. The fundamental question addressed by the BiOp is “Is it likely that fishing jeopardizes Steller sea lions?” Even if we use exactly the same scientific evidence and interpret it in the same way as the writers of the BiOp from NMFS, we may reach different answers to this question if we use different standards for “likely.”

The BiOp’s Standard for “likely”

The BiOp never defined the meaning of “likely” or indicated what standards it used to determine “likely”. Reading of the BiOp, however, suggests the BiOp applied an implicit standard of “possible” in drawing its most important conclusions, and in some instances it used a standard of “not impossible.”

This is evident in what is arguably the most important paragraph of the BiOp: the last paragraph of the “Conclusions” to the “Conclusions and Synthesis” chapter, the discussion of jeopardy (Section 7.4.5, page 345):

“Therefore, the Agency concludes in this Biological Opinion that, while fisheries cannot be unequivocally shown to be a causative factor in continued Steller sea lion declines in the western portion of the wDPS in Alaska, analysis of available data indicate that an adverse relationship between Steller sea lions and the commercial fisheries may exist in the western Aleutian Islands sub-region and portions of the central Aleutian Islands sub-region where two specific fisheries, for Atka mackerel and Pacific cod, target important Steller sea lion prey. This competition between Steller sea lions and the commercial fisheries may compromise the availability of food resources of Steller sea lions sufficiently to likely jeopardize their continued existence or to adversely modify their critical habitat. Only a small percentage of Steller sea lions remain in the western and central Aleutian Islands sub-regions relative to the pre-decline population level. Fishery removals of prey in the western and central Aleutian Islands sub-region may be adversely affecting the western DPS of Steller sea lions in these areas sufficient to stress animals through longer and less successful foraging trips and foraging trips that require more repetitive dives to acquire prey. The possibility that this interaction may be one of several primary causes of the observed declines in non-pup counts cannot be eliminated. Lack of site specific data on vital rates and food habits in the region where declines in abundance have been reported make our evaluation of what factors are impeding a robust rate of recovery of the western DPS difficult. Nonetheless, because of the weight of evidence described in this Biological Opinion and the requirements of the ESA, we must act in a precautionary and measured approach by changing fishery harvests in the sub-regions that have demonstrated declines in Steller sea lion numbers sufficient to impede recovery. After reviewing the current status of the endangered western population of Steller sea lions, the environmental baseline for the action area, the proposed actions, and the cumulative effects, it is NMFS’ Biological Opinion that the action, as proposed, is likely to jeopardize the continued existence of the western DPS of Steller sea lion.” [BiOp, 345]

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Note that the conclusion repeatedly states that effects “may exist”, and says that a “possibility cannot be eliminated”.

An important and revealing phrase in the conclusions cited above is:

“ . . . may compromise the availability of food resources of Steller sea lions sufficiently to likely jeopardize . . . ”

Note how “may have an effect which is likely to jeopardize” is being equated with “likely to jeopardize.” Put differently, the BiOp concludes that the effect of commercial fisheries on Steller sea lions “may be likely.” It is not obvious what “may be likely” means—although it sounds weaker than “likely.”

The Scientific Meaning of “likely”

The normal scientific meaning of “likely” is “probable” or “most likely.” Most scientists asked whether it is likely that A causes B will answer “yes” only if they think the weight of scientific evidence supports the conclusion, or at least that more scientific evidence supports the conclusion than other potential conclusions. Scientists will respond “it’s possible, but it’s not likely” if they think that some scientific evidence supports the conclusion, but more of the evidence supports other potential conclusions or is inconclusive.

As scientists reviewing the conclusions of the BiOp, these are the standards we expect other scientists to use in evaluating whether it is “likely” that fishing jeopardizes Steller sea lions. This is also the standard we were directed to use by our terms of reference:

Standards for our Review as Stated in the Terms of Reference

Do the conclusions represent *the most likely scientific explanation* for apparent population dynamics of the WDPS of SSL given the current state of knowledge?

Do the conclusions in the BiOp regarding the finding of jeopardy and its posited cause (nutritional stress from food competition with fisheries) *follow logically* from scientific, economic, and social information presented in the BiOp and attendant documents?

Are the conclusions contradicted by any scientific, economic, and social information not presented in the BiOp?

Were alternative scientific explanations to the apparent population dynamics of the WDPS of SSL *thoroughly considered*, such as explanations involving but not limited to predation, disease, ecosystem/carrying capacity, or emigration?

Do the Reasonable and Prudent Actions (RPA) imposed on the *fishery follow logically* from the conclusions regarding jeopardy?

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Qualifying conclusions in the BiOp using terms such as “may” and “the possibility cannot be excluded” indicates that the BiOp based its conclusion of jeopardy on a lower standard than the normal scientific meaning of “likely” or the standard we were directed to use in our review.

Where appropriate, we point throughout our review to the specific situations where this lower standard for “likely” was used. Like the hypothetical scientist who responds “it’s possible, but it’s not likely,” we point out specific conclusions of the BiOp which we consider to be “possible but not likely.”

More generally, we attempt to evaluate the relative weight of evidence for and against each link in the BiOp’s chain of reasoning as well as its overall conclusions. We also evaluate how “likely” we consider each link in the chain of reasoning to be, as well as the overall conclusions.

The Legal Standard for “likely”

The BiOp represents an enormous amount of science, and was written mostly by scientists. Its conclusions should therefore be based on science. However, the BiOp is also a legal document which was written in response to a legal requirement and contains conclusions that are legally binding.

Our understanding is that the appropriate standard for “likely” is ultimately subject to test and review in court, as is clear from this discussion at the North Pacific Fishery Management Council’s August 2010 meeting:

NPFMC Member Dan Hull:

“I’m still struggling with the issue of the use of best science in this whole process . . . At what point, and who decides what is the best available information to use?”

AFSC Chief Scientist Doug DeMaster:

“Can I get a counsel to respond first, and I can follow up?”

NPFMC Chair Eric Olson:

“Usually it’s the other way around.”

Doug DeMaster:

“I know, but it’s safer this way.”

NMFS Counselor:

“That has to do with the determination of what is ‘best available science’. Essentially that would be a determination of the secretary based on information that he has been provided by the experts in the agency. That would be tested—if in fact there was a concern about that—in court. And a court would, of course, use the arbitrary and capricious standard to determine whether the secretary was correct in that use of information.” [2010_8_19_946.mp3, 7:20]

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The following statement of AFSC scientist Doug DeMaster to the North Pacific Fishery Management Council at its August 2010 meeting implies that legal considerations may have influenced how conclusions were stated and qualified in the BiOp. :

“At least where I’ve been involved in the writing I’ve tried to put in the caveats ‘may’, ‘appearance’. Sometimes the lawyers, you know, like to be more definitive . . . No offense, John. But I have struggled with trying to put in caveats—and then, uh, then they disappear.” [2010_8_18_1108.mp3, 8:12]

We do not have or claim any legal expertise as to the appropriate *legal* standard for “likely” in reaching a conclusion of jeopardy. Our review is based on the relative weight of *scientific* evidence for and against each link in the BiOp’s chain of reasoning as well as its overall conclusions.

The Issue for Society in the Standard for “likely”

The appropriate definition for “likely” in reaching a conclusion of jeopardy is a critical issue faced by society in making the difficult choices of how to protect endangered species when there is only limited scientific understanding of how our actions affect those species. To what extent should certain groups in society (such as the fishing industry and fishing communities) be required to make real and substantial economic sacrifices in return for scientifically uncertain benefits for the survival and recovery of endangered species?

Consider the question “is it likely that fishing jeopardizes Steller sea lions?” There are two “wrong” ways this question could be answered. One could conclude that fishing jeopardizes Steller sea lions when in fact it does not (a false positive). Or one could conclude that fishing does not jeopardize Steller sea lions when in fact it does (a false negative). Relaxing the strictness of the standard for “likely” increases the chances of drawing a false positive conclusion, and correspondingly reduces the chances of a false negative (Table 2.2).

Table 2.2.—Implications of the standard for “likely” for probabilities of a false positive or a false negative conclusion.

Standard for “likely”	Strictness of standard	Probability of false positive (concluding that fishing jeopardizes Steller sea lions when in fact it does not)	Probability of false negative (concluding that fishing doesn’t jeopardize Steller sea lions when in fact it does)
Highly likely Probable Most likely Possible Not impossible	Higher ↑ ↓ Lower	Lower ↑ ↓ Higher	Higher ↑ ↓ Lower

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If the primary concern is to avoid a false negative (*i.e.*, concluding that fishing does not jeopardize Steller sea lions when in fact it does) that could potentially harm Steller sea lions, then a low standard should be adopted for “likely.” This is the essence of the precautionary principle referenced in the BiOp’s conclusions:

“Nonetheless, because of the weight of evidence described in this Biological Opinion and the requirements of the ESA, we must act in a precautionary and measured approach by changing fishery harvests.” [BiOp, 345]

But adopting a lower standard for “likely” increases the chance that high costs are imposed on fishermen and fishing communities without actually benefiting Steller sea lions. And it can be hard for people to accept making significant sacrifices in the absence of having good scientific evidence that the sacrifices are needed. Consider for example the public testimony at the August 2010 meeting of the North Pacific Fishery Management Council:

“This is something that is hyper-important to me as an individual. . . Having another vessel displaced or crews put out of business without the benefit of the doubt, without clarity as to the relationship between the sea lions’ disposition and what’s happening in fishing is highly problematic.”

“I don’t want to come here and make statements about how bad the science is. But it does seem that a lot of it is thrown together very loosely to come up to the conclusions they arrive at. . . . We are not fundamentally opposed to restrictions on us. But with good knowledge. Knowledge is important. Not the legal construct to dodge a bullet, but good, proper knowledge.”

“Let’s find some real truth, and operate on that. And if I have to get hit through real truth, I will take it. But not something that is so oddly constructed as to meet some bar that is sort of arbitrary and academic.” [Matt Doherty, 2010_8_19_248.mp3, 0:00]

Just as we claim no legal expertise as to the appropriate legal standard for “likely” in reaching a conclusion of jeopardy, we also claim no expertise as to where society should set the standard of scientific likelihood for taking actions which impose costs on some groups for uncertain benefits for the survival or recovery of a species. We only argue that whatever the standard, decisions should be based on the best possible understanding of the available scientific evidence, which is what we hope to contribute to in our review.

Good motives are not a substitute for good science. However strong and laudable the desire to protect an endangered species may be, it does not justify the assumption that restricting human activity will *necessarily* benefit a species or the environment. For example, Atka mackerel is an important prey species for Pacific cod. Thus, limiting Pacific cod harvests could in theory reduce stocks of Atka mackerel (which the BiOp asserts are nutritionally important for Steller sea lions). If this is the case, however well intentioned, restrictions on Pacific cod harvests could harm rather than help Steller sea lions.

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Our point here is not to endorse this or other similar nonlinear theories (which we discuss briefly in our review), but rather to make the point that a good motive does not necessarily equate to a good result. Science should always be based on the best available evidence.

Summary

The BiOp responds to the mandate in the ESA that “*Each Federal agency shall . . . ensure that any action . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat...*” In reaching or evaluating any conclusion about jeopardy, a key issue is the standard for “likely.” The lower the standard, the easier it is to meet.

The BiOp never defined the meaning of “likely” or indicated what standards it used to determine “likely”. Reading of the BiOp, however, suggests the BiOp applied an implicit standard of “possible” in drawing its most important conclusions, and in some instances it used a standard of “not impossible.”

The normal scientific standard for “likely” is “probable” or “most likely.” Qualifying conclusions in the BiOp using terms such as “*may*” and “*the possibility cannot be excluded*” indicates that the BiOp based its conclusion of jeopardy on a lower standard than the normal scientific meaning of “likely” or the standard we were directed to use in our review.

The appropriate definition for “likely” in reaching a conclusion of jeopardy is a critical issue faced by society in making the difficult choices of how to protect endangered species. We claim no expertise as to where society should set the standard of scientific likelihood for taking actions which impose costs on some groups for uncertain benefits for the survival or recovery of a species. However, whatever the standard, decisions should be based on the best possible understanding of the available scientific evidence.

3. STATISTICAL RELATIONSHIPS BETWEEN FISHERIES AND STELLER SEA LION POPULATIONS

The BiOp contains an incomplete review of the effort that has been expended over the years to find statistical associations between aspects of commercial fishing and the demographics of Steller sea lions of the western population (WDPS) (Loughlin and Merrick 1988; Ferrero and Fritz 1994; Dillingham *et al.* 2006; Hennen 2006; Soboleff 2006; Calkins 2009; AFSC 2010; and Trites *et al.* 2010 are cited). Quoting the BiOp:

“Correlations between western SSL trends in abundance to commercial groundfish fisheries are highly varied, some positive, some negative, and some spurious.” [BiOp, xxx], and

“Some (researchers) have found no significant correlations between certain fishing techniques (such as longline fisheries) or target fisheries (such as Aleutian Islands Atka mackerel) and SSL trends.” [BiOp, xxx], and

“Statistical and correlative analyses of fishery effort/catch with trends in local Steller sea lion populations have yielded equivocal results, some indicating a positive and some a negative relationship between catch and Steller sea lion population trends.” [BiOp, 237]

In addressing what the BiOp considers as “equivocal” results, NMFS concluded in their synopsis:

“At this time with available data, it is not possible to demonstrate a statistically significant relationship between commercial fisheries on pollock, cod, Atka mackerel and arrowtooth flounder and the productivity of Steller sea lions in the western DPS. However, it is also not possible with the available data to conclude that commercial fisheries are not having a significant impact on the recovery of the western DPS of the Steller sea lion.” [BiOp, 301]

The BiOp provides no statistical description or justification as to why results from the cited papers were considered “equivocal”. In conducting our review, we concluded that a realistic appraisal of these studies provides strong evidence *against* a finding of JAM.

Statistical Meta-Analysis

Table 3.1 is a summary of the statistical studies cited in the BiOp plus two more, Sampson (1995) and Hui (2011), the latter being published after the BiOp was signed. Although these 10 studies involve different metrics, different methods, and cover different time series of different lengths, they are all based on statistical testing. All statistical tests are subject to two types of error: detecting an association that does not exist, or not detecting an existing association. In the

Table 3.1.–Summary of studies looking for statistical relationships between fishery or prey biomass and sea lion variables. Shaded area corresponds to results *inconsistent* with fisheries having a negative effect on sea lion demographics.

Reference	Location	Taxa	Years	Fishery Variable	SSL Variable	No. Significant at $\alpha = 0.05$		
						Neg	NS	Pos
Loughlin and Merrick 1989	WDPS	pollock	1976-1986	Catch	No. non-pups, No. pups	2	32	2
Ferrero and Fritz 1994 ^a	Areas 541-3, 610	pollock	1976-1991	Catch	No. non-pups	2	18	0
Sampson 1995 ^b	WDPS	G fish	1979-1990	Catch, Effort(hrs)	No. non-pups, No. pups	1	78	1
"	"	Atka m	"	"	"	0	40	0
"	"	P cod	"	"	"	0	40	0
"	"	pollock	"	"	"	0	39	1
Soboleff 2005	WDPS	P cod	1976-2002	Catch (AK fishery)	No. non-pups	0	6	0
"	"	pollock	"	"	"	0	6	0
Hennen 2006	WDPS	G fish	1977-1991	No. hauls, CPUE	No. non-pups	10	8	0
"	"	"	1991-2002	"	"	0	15	3
Dillingham <i>et al.</i> 2006	Areas 541-3, 610	Atka m	1977 - 2002	Prey Biomass density ^c	Growth Rates Non-pups	0	1	0
"	"	P cod	"	"	"	0	1	0
"	"	pollock	"	"	"	1	0	0
Calkins 2009	WDPS	P cod	1996-2000	No. hauls, CPUE	No. non-pups	4	1	0
"	"	"	2000-2004	"	"	0	13	7
Trites <i>et al.</i> 2010	Areas 541-3	Atka m	2000-2009	No. hauls, Catch, CPUE	No. non-pups	0	19	8
AFSC 2010a ^d	Areas 541-3, 610	Atka m	1991-2008	Harvest rates	Growth Rates Non-pups	0	3	0
"	"	P cod	"	"	"	0	2	1
"	"	pollock	"	"	"	0	3	0
Hui 2011 ^e	Areas 541-3	Atka m	2000-2008	Prey Biomass ^f	Growth Rates Pups, non-pups	0	16	0
"	"	P cod	"	"	"	0	16	0
"	"	pollock	"	"	"	0	16	0

^a This study also involved areas east of the Aleutian Islands that were not involved with the finding of JAM in the BiOp.

^b Ignored correlations for 3rd and 4th principle components at author's suggestion (components represent negligible amounts of variation). Also, this study not cited in BiOp.

^c Biomass density is not a fishery variable. Estimates of biomass come from periodic synoptic trawl surveys.

^d Authors used the unconventional standard of $\alpha = 0.25$.

^e Study published after BiOp signed.

^f Biomass is not a fishery variable. Estimates of biomass come from periodic synoptic surveys.

cited studies an association is between groundfish fisheries and Steller sea lions or prey biomass and sea lions. The probability of the first type of error is α , and the statistical (scientific) convention is $\alpha = 0.05$, that is, a 1-in-20 chance of finding an association that does not exist. The probability of the other type of error is β , and $1 - \beta$ is called the power to detect an existing association. The larger the sample size with α fixed at 5%, the greater the power of the test. Depending on the metrics used in the test, statistically detecting negative, positive, or no associations at all have different scientific interpretations. Shaded cells in Table 3.1 represent outcomes from statistical testing that indicate *no* negative impacts of groundfish fisheries on Steller sea lions; clear cells represent outcomes that indicate *possible* impacts.

Early statistical studies listed in Table 3.1 were based on a limited number of years, and as such, their tests had limited power to detect associations between fisheries and sea lions. The proportionally high number of non-significant outcomes reported in these early studies is consistent with this lack of power. The only early study specific to Steller sea lions in the Aleutian Islands during these early years is Ferrero and Fritz (1994) in which two of 20 tests involving fishing for pollock had statistically significant associations, and both of those were *negative*. Given $\alpha = 0.05$, one statistically significant outcome out of 20 tests would be expected due to chance alone.

Studies published after 2000 had the benefit of more years of data and therefore more power to detect negative and positive associations between fisheries and sea lions. Hennen (2006) for groundfish in general and Calkins (2009) for Pacific cod fisheries found non-significant and statistically *negative* associations up to 1991 (Hennen) or up to 2000 (Calkins) in the WDPS of Steller sea lions as a whole. However, after those years, tests in both studies shifted to non-significant outcomes and statistically *positive* associations. Studies analyzing fishery data from Areas 541 – 543 after year 2000 (AFSC 2010; Trites *et al.* 2010) showed *no significant negative associations, only positive ones and non-significant outcomes* (Table 3.1).

Significant *positive* associations between statistics describing sea lion and fisheries are not evidence of “*equivocal*” or “*spurious*” results, but are evidence of a third factor that positively affected both fishery and sea lions. All significant associations in the studies cited in Table 3.1 had one attribute in common: the fishery always represented a minor component of the variation (<35%) in sea lion counts or growth rates.

The power of tests in the more recent studies cited in Table 3.1 was often estimated directly in those studies or could be inferred by their results. Soboleff (2006) estimated the power of his six tests involving the state pollock fishery such that he had on average a 3-in-4 chance of finding an existing association with Stellar sea lions; and for the state Pacific cod fishery a 9-in-10 chance on average. Calkins (2009) estimated that his tests had enough power to detect at least an annual 2% change in non-pup counts related to fisheries. While the results of these two studies seem to be somewhat at odds (Calkins found some negative associations, and Soboleff did not), note that two different sets of fisheries were involved—one federal and the other state. Although only Hui (2011) of the other studies listed in Table 3.1 considered the power of their tests, a closer look at the results of Trites *et al.* (2010) proves instructive. Note that measurement error and lack of variation would prevent finding statistically significant relationships of both kinds, *positive as well as negative*. Yet Trites *et al.* (2010) found 8 out of 27 relationships statistically significant

and *positive* (the eastern Aleutian Islands were not included in their analysis). The expected number of significant results by chance given a standard of $\alpha = 0.05$ is at most one positive and one negative. Because the power was obviously present to *flag 8 positive associations*, the power was there to flag negative ones as well. But no negative associations were detected.

Calkins (2009) deserves special mention because it is the only statistical investigation of the effectiveness of fishery restrictions from previous BiOps for the WDPS in general, including sea lions in the eastern Aleutian Islands and the Gulf of Alaska (GOA). In comparing metrics from long-line fisheries for Pacific cod to non-pup counts for the WDPS from 2000 – 2004, Calkins found 13 statistically non-significant outcomes, 7 significant positive associations, and 0 significant negative associations. As mentioned above, the power of these tests was sufficient to detect a 2% annual change in non-pup counts. Annual changes in non-pup counts in the WDPS were large enough for negative effects of fisheries to be detectable (Table 3.2) in all areas except the central Aleutian Islands.

Because all the statistical studies in Table 3.1 are observational studies, there are issues with the validity of their results in regard to auto-correlation in time series of data used in their tests, measurement error in those data, and using the same data in more than one test. Ignoring auto-correlation creates more “significant” outcomes than warranted; measurement error reduces the power of tests; and reusing data overstates the true number of independent tests. Note that not all studies in Table 3.1 are affected equally by these issues. Measurement error is probably more of an issue when estimated prey biomass is involved in the test (Dillingham *et al.* 2006; Hui 2011). We go into more detail on problems with measurement error in biomass estimates in the next chapter. Because ignoring auto-correlation never *reduces* the number of significant outcomes from a battery of tests, ignoring auto-correlation casts doubt on the statistical significance only for those associations expected from fisheries having a *negative* impact on sea lions. A scientific judgment of no impact would remain unaffected. The next section has more on these statistical issues as they pertain to one particular study.

Table 3.2.–“Counts and average annual trends of adult and juvenile (non-pup) Steller sea lions observed at rookery and haul-out trend sites surveyed consistently since 1991 in seven sub-regions of the western DPS in Alaska during June-July aerial surveys from 2000 to 2008.” [From BiOp, Table 3.1c]
Information has been reduced from the original table to facilitate calculating rates of annual change over a four year span.

Year	Western AI	Central AI	Eastern AI	Western GOA	Central GOA	Eastern GOA	All WDPS
2000	1,633	6,560	4,990	3,996	4,555	2,102	23,836
2004	1,286	6,885	5,991	5,233	4,028	3,015	26,438
Annual Change	-5.8%	+1.2%	+10.7%	+7.0%	-3.0%	+9.4%	+2.6%

The Foot-Print Analysis

The penultimate entry in Table 3.1, AFSC (2010a), requires particular attention in our review. Of the extensive list of statistical studies and analyses, NMFS appears to only use AFSC 2010a to base their conclusions about the effects of fine-scale fishery harvest and Total Allowable Catch on Steller sea lions in each of the rookery cluster areas (RCAs):

“The NMFS (2010a) biomass by RCA estimates are based on age 0+, 1+ or 2+ biomass for most stocks in order to quantify the prey available to sea lions (GOA and Bering Sea pollock are the exceptions).”[BiOp, 223, footnote 20]

This is also supported by the statement that:

“The AFSC also has conducted various Fishery Interaction Team studies (described previously), and additional analyses were conducted for this Biological Opinion (AFSC 2010a).”[BiOp, 282]

Thus, AFSC 2010a appears to be the key document upon which the BiOp based its assessment of competitive interactions between fisheries and Steller sea lions and NMFS’ judgment that results of statistical tests have been equivocal.

Despite its importance to the conclusions drawn in the BiOp, it is unclear what the AFSC 2010a document actually is. The citation section of the BiOp lists two possible corresponding documents for “AFSC 2010a” [BiOp, 385]:

AFSC (Alaska Fisheries Science Center). 2010a. Untitled. AFSC comparisons of SSL population changes 1991-2009 relative to the spatial and temporal distribution of SSL prey species, fisheries for these prey species, and various oceanographic measures of the North Pacific. AFSC manuscript. 74 p.

Alaska Fisheries Science Center (AFSC). 2010a. Steller Sea Lion Fishery and Oceanographic Analysis BiOp 2009 (October 22, 2009). 78 pages. Unpublished report, available Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way, NE, Seattle, Washington 98115.

We were unable to locate the first of these listed documents. This second listed document is also not the final report analysis as it was later updated and posted on the NOAA website (but not listed in the cited literature) as:

Alaska Fisheries Science Center (AFSC). 2010. Steller sea lion fishery and oceanographic analysis BiOp 2010 (February 11, 2010). Unpublished report, available from Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way, NE, Seattle, Washington 98115. 81 pp. (http://alaskafisheries.noaa.gov/protectedresources/stellers/esa/biop/draft/afsc_ssl_fishery_analysis0210.pdf)

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This is the document that was reviewed in public comments submitted to NMFS on the draft BiOp, as well as by the SSC of the North Pacific Fisheries Management Council in August 2010. There is no indication that this document was updated or changed in light of the comments received (based on the citation contained in the final BiOp, as well as being the only document posted on the NMFS website).

This unpublished AFSC (2010) report has been commonly referred to as the “footprint analysis”. It concluded there were many statistically significant relationships between changes in sea lion numbers and harvest rates of pollock, Atka mackerel and Pacific cod. This analysis was reviewed by the North Pacific Fisheries Management Council’s SSC (Scientific and Statistical Committee 2010), and is the one that we assumed formed the basis for the conclusions drawn in the final BiOp that fishing was negatively affecting Steller on sea lions. We found no indication that this AFSC 2010 report was subsequently updated. The BiOp acknowledges being told of errors in their assessment, but makes no mention of whether NMFS agreed and took appropriate action:

“In the August 2, 2010 draft Biological Opinion, NMFS reported biomass by RCA according to methods in AFSC (2010a). During the special Council meeting convened in August 2010, the SSC noted that the available data, particularly for patchily distributed Atka mackerel abundance, do not support apportionment at the scale of the RCAs. The SSC recommended that methods and scale used by the fishery stock assessment authors to determine and apportion biomass be used in the Biological Opinion as they comprise the best data available.” [BiOp, 283]

A number of reviews have already pointed out that the AFSC (2010) is a flawed analysis that drew erroneous conclusions that are not supported by the data or by independent scientific review (see public comments submitted on the Draft BiOp and SSC 2010). AFSC (2010) remains posted on the NOAA website with no retraction or correction — and continues to disseminate misleading and unscientific conclusions. As noted by the SSC (2010), the fishery survey data used in the AFSC 2010a report were insufficient to support analyses at the scales of the 11 RCAs, and the treatment of the data by the Alaska Fisheries Science Centre created artificial data with unknown accuracy. The SSC also pointed out that the AFSC likely overstated the significance of their linear regressions because they artificially increased their sample sizes (*i.e.*, they used the same years in different time periods). They also noted that linear regressions were not an appropriate statistical means for relating population growth rates to estimated harvest rates because of the large errors in the independent variable.

The SSC similarly criticized the AFSC for using $\alpha = 0.25$ to conclude that slopes of regressions between sea lion numbers and catch rates were statistically significant rather using the scientific standards for the chance of making an error ($\alpha = 0.01, 0.05$ or 0.10). Had NMFS applied the conventional error rate of $\alpha = 0.05$ to AFSC (2010), they would have concluded there were no negative relationships between fisheries and sea lions (shown in our Table 3.1 where we used the $\alpha = 0.05$ convention applied by all other studies).

Finally the SSC pointed out that the spatially defined data series used in the regressions were strongly auto-correlated, which would have reduced the effective sample size and increased the

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effective rate α (which would also have contributed to the already large number of significant relationships at $\alpha = 0.25$ that the AFSC claimed occurred between population growth rates and oceanographic variables in the Aleutian Islands).

Despite the criticisms by the SSC of the AFSC 2010a analysis in the draft BiOp, the AFSC document is posted on the NOAA website as credible science using misleading harvest rates that form the bases for RPAs in the final BiOp. This flawed analysis (AFSC 2010) appears to be a major underpinning of the BiOp's overall conclusion (*i.e.*,:

“NMFS concludes that the relative intensity of groundfish fisheries as currently prosecuted within critical habitat is negatively associated with Steller sea lion population response since 2000”. [BiOp, 348]

NMFS failed to correct their AFSC (2010) analysis and did not undertake a credible analysis of the spatial and temporal overlap of fisheries and Steller sea lions (see our Chapter 4). There is no indication in the BiOp that NMFS seriously considered the findings of others that did not find significant relationships between fisheries and sea lions (*e.g.*, Dillingham *et al.* 2006; Guénette *et al.* 2007; Trites *et al.* 2010).

One interpretation of the findings of these independent analyses of fisheries data is that there is no relationship between groundfish fisheries and the decline of sea lions. This possibility is not considered in the BiOp. Instead, the BiOp concludes that:

“... it is not possible to demonstrate a statistically significant relationship between commercial fisheries on pollock, cod, Atka mackerel and arrowtooth flounder and the productivity of Steller sea lions in the western DPS.” [BiOp, 301]

This conclusion casts serious doubt on the hypothesis that fishing caused the decline of sea lions in the Gulf of Alaska, Bering Sea and Aleutian Islands—and implies that NMFS does not accept scientific findings that do not conclude that fishing caused the decline of sea lions. The BiOp does not explain why a statistically significant relationship cannot be demonstrated, and fails to demonstrate the mechanism by which fishing caused the decline of sea lions. The assertion that the overfishing hypothesis is untestable ultimately means that the BiOp's conclusion that fishing must be jeopardizing sea lions is untouchable and cannot be refuted. The fact that studies conducted since 2000 have failed to find a relationship between fisheries and sea lion numbers is not a reason to conclude that the fishing hypothesis is untestable.

Summary

In our opinion collective results of reported statistical studies involving Steller sea lions in the WDPS and groundfish fisheries are not *“equivocal”*, but are definitive. Statistical tests in earlier studies were based on a few years of data, and as expected, the subsequent low power produced mostly statistically non-significant outcomes with a few negative and a few positive associations being statistically significant. These results *are* equivocal.

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Studies published after 2000 involved more years and consequently had more power to detect an association between fisheries and Steller sea lions. Results from these studies were less equivocal in that 40% of tests produced statistically significant associations for years prior to 2000 that were consistent with a negative impact from fishing; the remaining 60% of tests had statistically non-significant outcomes which is consistent with fisheries *not* having a negative impact on sea lions. These results are still somewhat equivocal because there are some methodological issues concerning effective statistical error in the some of the tests, and because associations, though detected, were weak.

However, results for years after 2000 are *unequivocal*. No statistically significant associations consistent with harm by fisheries were found: *100% of the tests resulted in outcomes consistent with groundfish fisheries having had no impact on sea lion demographics*. Power analyses in those studies and the results themselves show that even weak negative associations would have been detected had they been present. Without some plausible reason for failing to find any statistical outcomes consistent with negative impacts for the last 10 to 20 years, the statement that “*it is not possible ... to conclude that commercial fisheries are not having a significant impact on the recovery ...*” is scientifically wrong.

In this BiOp, NMFS failed to appropriately evaluate past statistical studies done by others, and did a poor job of conducting their own statistical analysis. NMFS did not explain why a statistically significant relationship cannot be demonstrated between the metrics of fishing and changes in sea lion numbers and trends. They did not show strong direct evidence of a mechanism by which fishing caused a decline, and fell short in explaining an ecological relationship between fishing and sea lions that in all likelihood does not exist (see Chapter 4). As such, the hypothesis of a negative relationship between fishing and sea lion populations should have been rejected.

4. THE BIOP'S EXPLANATION OF THE ECOLOGICAL RELATIONSHIP BETWEEN FISHERIES AND STELLER SEA LIONS

The ecological hypothesis posited in the BiOp that groundfish fisheries in the BSAI management area and elsewhere negatively affect recovery of Steller sea lions in the western and central Aleutian Islands is scattered throughout the text:

“The most notable indirect effect of commercial fisheries on Steller sea lions is the removal of prey species which could alter the animal’s natural foraging patterns and their foraging success rate;” [BiOp, 198]

A sustained reduction of prey resources across a broad geographic region (i.e., ecosystem) would thus reduce the carrying capacity of Steller sea lions. These potential impacts have generally been referred to as nutritional stress (see Section 3.1.14).” [BiOp; xxxii, 199, 347]

Other quotes used to describe the hypothesis are more speculative judging from the liberal use of “may”, “can”, and “possibly”:

“Both regional and localized fisheries removals of prey could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways. Changes in the overall energy density of the prey field due to both climate shifts and long-term fisheries impacts (e.g., exploitation strategy), may have reduced the foraging efficiency of Steller sea lions and affected their ability to obtain adequate energy to maintain body condition and full reproductive potential.” [BiOp; xxiv, 336]

“While specific mechanisms related to competitive interactions between SSLs and commercial fisheries are difficult to verify, it appears that commercial fisheries, at least in the western and parts of the central Aleutian Islands, may remove fish that are prey for SSLs that forage there, or may draw down biomass levels in the general region, affecting prey availability in nearshore areas where SSLs prey most heavily.” [BiOp; xxxi, 343]

“A reduction in prey resources may result in a reduction in population growth rate. Specifically, reduced prey availability can lead to physiological responses by Steller sea lions that directly (e.g., reduced natality) or indirectly (e.g., increased mortality from predators due to increased foraging) reduces their population growth.” [BiOp, 199]

“NMFS concludes based on available information that State managed fisheries for pollock, Pacific cod, herring, and salmon are likely to continue to compete for fish with foraging Steller sea lions. Given the importance of near shore habitats to Steller sea lions, this competition for fish may have consequential effects.” [BiOp, xxxii]

A less speculative, graphical description of the hypothetical ecological mechanism between fisheries and sea lions is presented in Figures 4.1 and 4.2. The former is a schematic on how

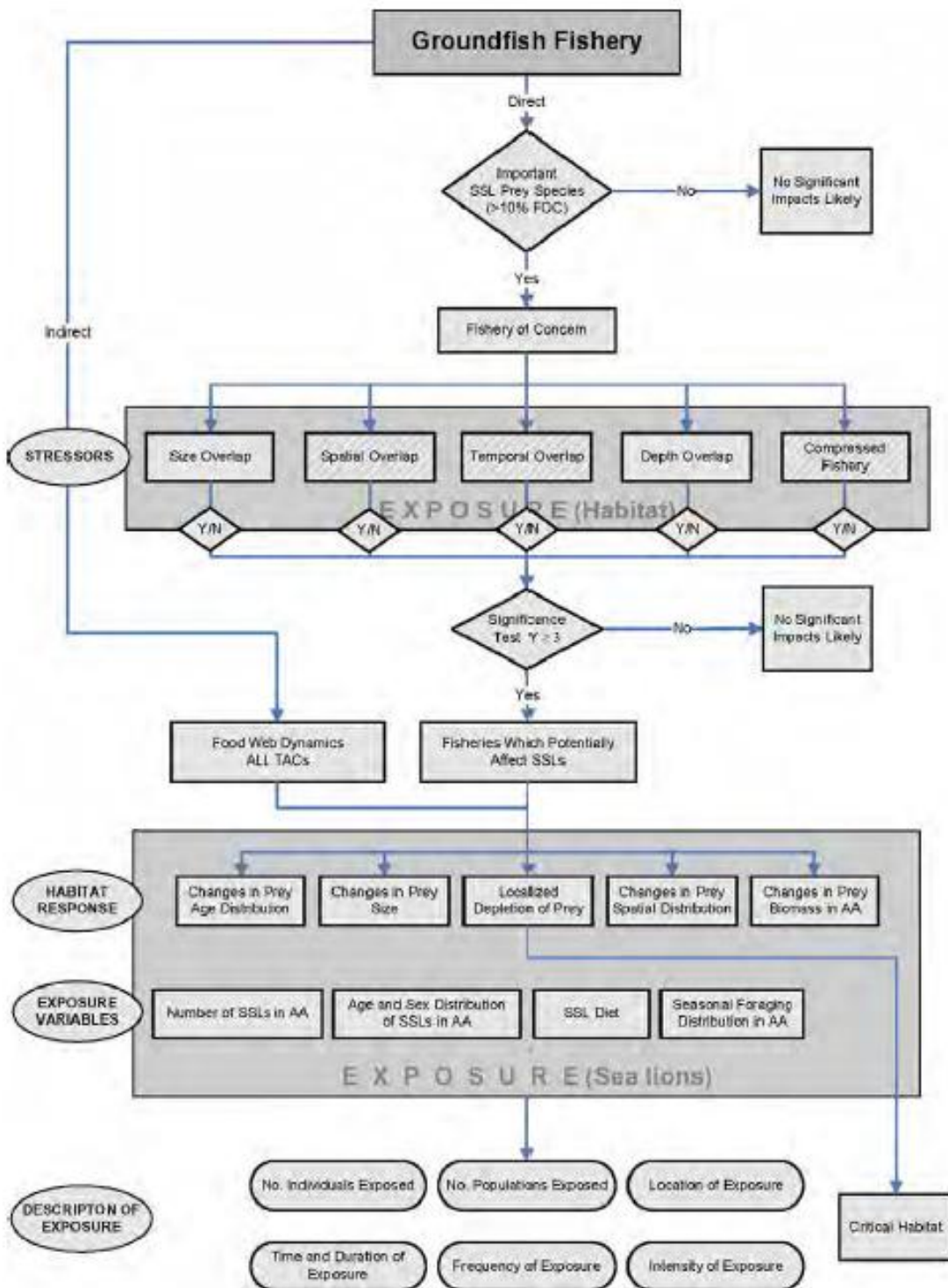


Figure 4.1.— “Exposure risk schematic.” This schematic represents that part of the “nutritional stress” theory of the interactions between fisheries and Steller sea lions that result in exposing sea lions to the risk of negative demographic effects. [Figure 4.1 is BiOp, Figure 4.24]

Response Analysis (Habitat Based): Competition for Prey

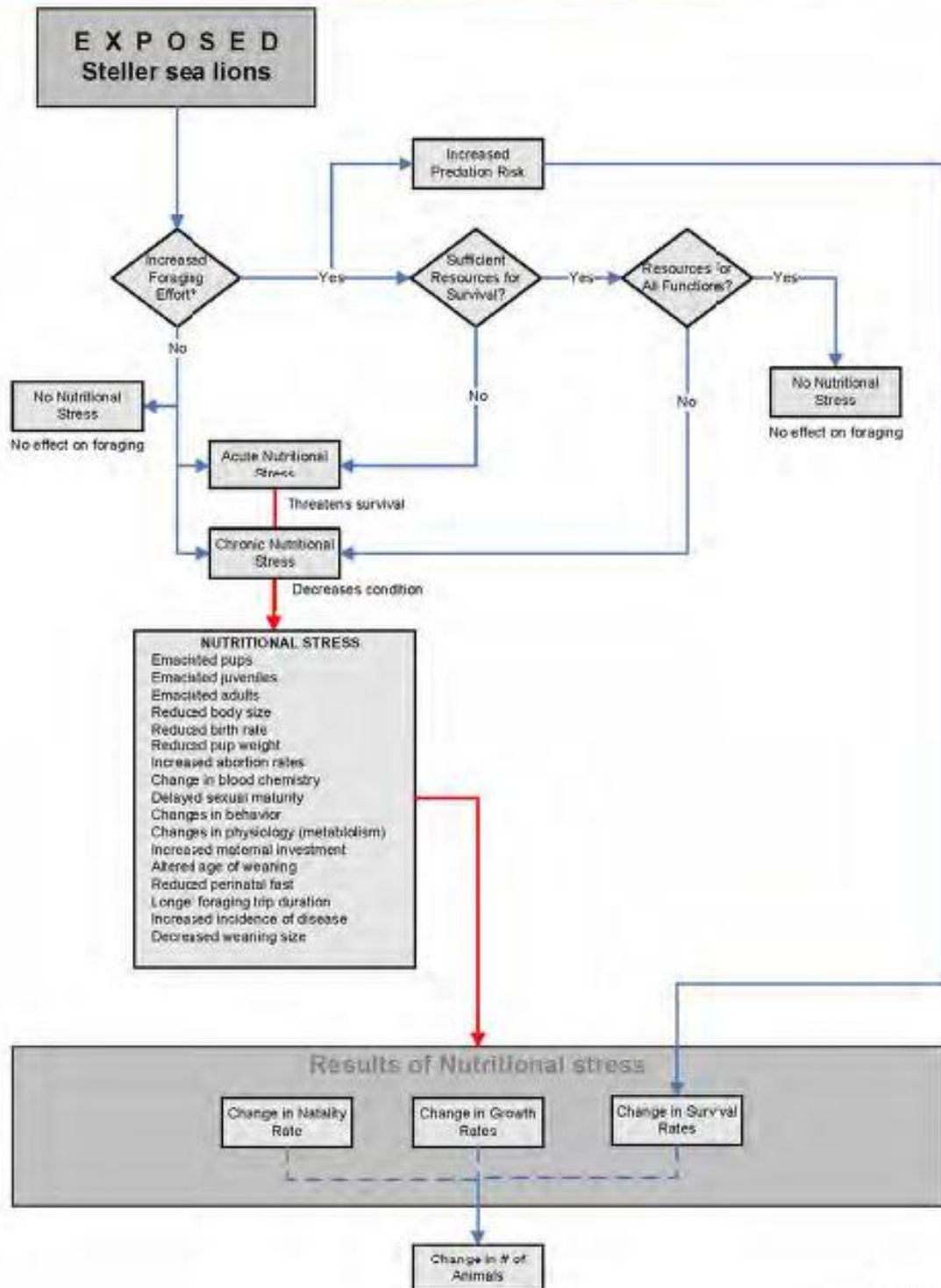


Figure 4.2. –This schematic represents that part of the “nutritional stress” theory of the interaction between fisheries and Steller sea lions where exposure to risk results in actual negative demographic effects. [Figure 4.2 BiOp, Figure 4.25]

fishing could potentially “expose” sea lions to risk of having a smaller prey field (less food), and the latter is a schematic on how the demographics of sea lions “exposed” to smaller prey fields might subsequently “respond” with smaller numbers of sea lions.

Our review of the BiOp follows the schematics (Figures 4.1 and 4.2) that ostensibly led the BiOp to the finding of JAM. We review the scope of the schematics, the relevance of the criteria used in making decisions, and the evidence used in the decision-making process. We begin with the process of judging the risk of exposure of sea lions to fishing for Atka mackerel and Pacific cod in the western and central Aleutian Islands and elsewhere (collectively AA in the schematics).

Risk of Exposure

The first decision point in Figure 4.1 is whether or not a fishery is of concern. An arbitrary standard was ambiguously applied in making this decision. The BiOp considered species with 10% or more frequency of occurrence (FO) in the diets of sea lions to be important prey, but provide no rationale for setting this standard. Frequency of occurrence is the percentage of fecal samples that contained the parts of one or more individual species of prey or taxa. They do not sum up to 100%, which means that a species with a 10% frequency of occurrence could ultimately represent less than 1% of a sea lion diet. Similarly, if every sea lion ate some pollock and some cod, the frequency of occurrence would be 100% for pollock and 100% for cod, but collectively they would probably each make up less than 50% of the diet. No rules were given as to how the FO *for a species* was calculated, and whether the 10% was to be compared with the highest FO observed by area, by season, or by a combination of area and season, etc. Arbitrary and ambiguous rules can make for arbitrary and ambiguous decisions.

The BiOp considered fisheries for Atka mackerel and Pacific cod to be fisheries of concern. The decision for the Atka mackerel fishery is consistent with the importance of Atka mackerel in the sea lion diet, but the decision regarding Pacific cod fisheries is not consistent with the dietary information in NMFS (2006) (Table 4.1) or in Sinclair and Zeppelin (2002) (Figure 4.3). The demonstrated prey field for sea lions in the western and central Aleutian Islands is varied, but is dominated by Atka mackerel (see [BiOp, Figure 3.8]) with the next species representing a distant second tier.

Regardless of the season, Atka mackerel appear to be eaten by most sea lions in the western and central Aleutian Islands. In summer, salmon and cephalopods form the second tier in the prey field. In winter Pacific cod, Irish lords, cephalopods, and arguably salmon are in that second tier. Information on diets in studies prior to 1990 is based on too few samples upon which to prudently draw inferences (see [BiOp, Table 3.14]). Selecting Atka mackerel as a potential “fishery of concern” is relatively easy to accept, but a scientific explanation is needed about the rules the BiOp applied to conclude that the fishery for Pacific cod is a “fishery of concern”.

Exposure of Habitat to Fishing

The second round of decision points (Figure 4.1) dealing with “EXPOSURE (of) Habitat” are arbitrary, ambiguous, and incomplete. They include questions pertaining to the overlap between what (size), where (depth and location), and when a prey species is caught in fisheries and by sea

Table 4.1.—Frequency of occurrence of prey in percent of scats collected from 1999 – 2005 at rookeries and haul outs used by sea lions in the western and central Aleutian Islands (areas 541 – 543). [from NMFS (2006)]

Region	Central & Western Aleutians	
Season	Summer	Winter
Number of scats	483	301
Pollock	7	12
Pacific cod	6	26
Atka mackerel	96	55
Salmon	17	6
Herring		
Sand lance	4	1
Arrowtooth	1	1
Irish Lord sp.	3	23
Sand fish	1	5
Halibut		1
Cephalopods	13	18
Rock sole	0	6
Snailfish sp.	1	12
Capelin		
Poacher sp.		

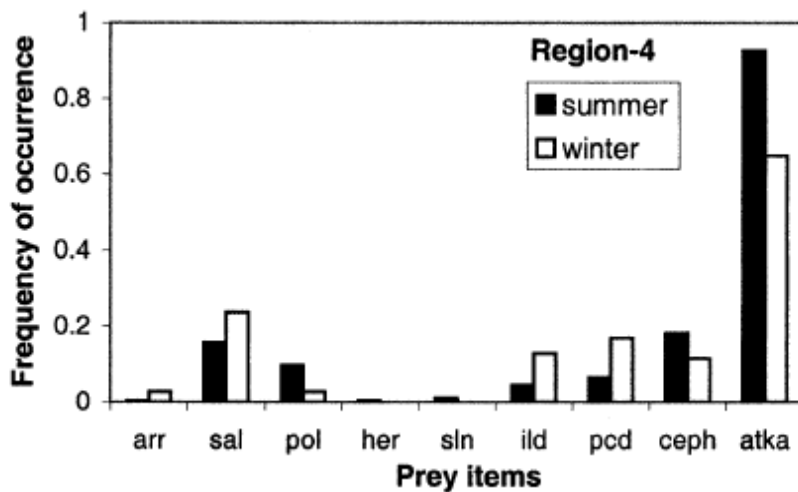


Figure 4.3.—Frequency of occurrence of prey in 2430 scats in summer and 1843 scats in winter collected from 1990 – 1998 at rookeries and haul outs in their region 4 (approximately Area 541 – 543) [from Sinclair and Zeppelin (2002)]. Prey abbreviations are arr=arrowtooth flounder, sal=salmon, pol=pollock, sln=sand lance, ild=irish lord, pcd=Pacific cod, ceph=cephlapod, and atka=Atka mackerel.

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lions. The final decision in this suite concerns the degree to which fisheries compete in time and space for species (*i.e.*, the overlap and the compression of competing fisheries). An answer of “yes” for 3 or more of these decision points result in a conclusion that the fishery was potentially affecting sea lions. There is no explanation in the BiOp for why three, or for giving equal weights to all decision points. Nor is there any discussion of how much overlap is too much or too little or sufficient for concluding there is some significant degree of overlap. The BiOp is mute on these questions, but makes the following conclusions:

“4.5.3.1 Overlap: Size of Prey ... Evaluation of the overlap is confounded by a number of factors.” [BiOp, 235]

“4.5.3.2 Overlap: Depth of Prey. Depth overlap between foraging Steller sea lions and fisheries may occur for any species taken by fisheries on the shelf or shelf break. Competition may be less likely for species found deeper in the water column. The extent to which competition between fisheries and Steller sea lions may be avoided through partitioning of resources by depth can be difficult to judge using the available information. Scientific studies of Steller sea lion foraging patterns are just beginning to characterize the diving depths and patterns of Steller sea lions, and they (sea lions) are likely capable of foraging patterns not yet understood or anticipated. Describing the overlap in depth between fisheries and Steller sea lions is further complicated by diel or seasonal vertical migrations of the fish resources for reproduction, refuge, or foraging.” [BiOp, 235]

There is nothing definitive in the BiOp relative to how decisions on exposure can be based on size of prey or the depth at which they are taken. Text on compressed fisheries in the BiOp is just as ambiguous, but does seem to suggest that the long-line fishery for Pacific cod is less likely to contribute to JAM:

“4.5.3.5 Overlap: Compressed Fisheries. ... Observer data were used (section 5.3.1.6 and Figures 5.1 and 5.2 in NMFS, 2001) to describe concentration in time and space for BSAI trawl, pot, and hook-&-line fisheries (Figure 4.31). ... These data suggest that the hook-&-line fishery is more dispersed than the trawl fishery, and may be less likely to cause localized depletions of prey. ... Some published papers (Løkkeborg 1989; Lokkeborg 1998; Lokkeborg and Ferno 1999) have looked at the effects of gear such as hook-&-line on the distribution and abundance of fish species. Hook-&-line fisheries appear to be more dispersed in both time and space - one of the fishery components which would reduce the likelihood of resulting in adverse modification of critical habitat (NMFS 2001, 2003).” [BiOp, 240]

The decision point concerning temporal overlap between fisheries and sea lions will always be answered “yes” for those fished species in Table 4.1. Sea lions in the western and central Aleutian Islands rely on the same species for sustenance year round (mostly Atka mackerel), so regardless of when the fishery occurs, the catch will come from the same stock of prey.

Text in the BiOp concerning spatial overlap of fisheries and the prey field of sea lions was limited to local depletion of prey within critical habitat (see section “4.5.3.3 Overlap: Spatial

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(Evidence for Localized Depletion of Important Prey): [BiOp, 235]). This is the only decision point among the five supported by a written judgment as to whether or not there had been some local depletion of prey species in the CH within the BSAI area. For Pacific cod:

“Opportunistic tag release and recovery data collected as part of the FIT experiments suggests a high rate of movement through the study area (of Pacific cod). This is a compelling explanation for why no localized decreases in cod were observed, despite high levels of fishery catch (NMFS 2006b).” [BiOp, 236]

“During a 1.5 month fishing period in 2001, cod abundance (as reflected by changes in fishery catch per unit effort) in the focal area north of Unimak Island declined significantly and this apparently was not related to large-scale emigration. (see Fritz and Brown 2005)”. [BiOp, 236]

“Based on all the available evidence, it is not possible to definitively conclude that the fishery north of Unimak Island does not affect foraging efficiency of Steller sea lions within their critical habitat by reducing densities of Pacific cod during winter (when the frequency of occurrence of cod in their diet is the highest).” [BiOp, 237]

The decision concerning spatial overlap vis-à-vis Pacific cod is given later in the BiOp:

“Exclusion zones are less effective in those areas where zone boundaries cut across habitat where fish would be expected to move freely (e.g., Pacific cod; Figure 5.3), thus allowing fisheries outside to negatively influence prey populations thought to be protected inside the zone (e.g., Amchitka). FIT and other studies of trawl exclusion zone effectiveness around Cape Sarichef (Unimak Island) have shown similar results with respect to the Pacific cod trawl fishery on the southeastern Bering Sea shelf (Fritz and Brown 2005; Conners and Munro 2008).” [BiOp; 292-3, 340]

A decision of “yes” to spatial overlap given in the BiOp is a logical fallacy commonly called an *argumentum ad ignorantiam*, or an “appeal to ignorance”. The fallacy of the argument is that a proposition is true because it has not been proven false.

Concluding there is significant spatial overlap for Atka mackerel is based on limited migration by this species and estimates of exploitation rates for specific areas:

“Tagging-based estimates of movement rates show low movement from inside to outside the trawl exclusion zone at Seguam Pass, Tanaga Pass and Kiska Island. In contrast, the movement rate from inside to outside the trawl exclusion zone at Amchitka Island was high.” [BiOp, 235]

“To further examine the potential for localized depletion of Atka mackerel, exploitation rates (catch/biomass) were calculated for the Atka mackerel fishery during August through October in each of the Atka mackerel tagging areas. Catch data were derived from the Norpac database and represent all Atka mackerel catches by observed commercial catcher processors in each of the specific study areas. The local

exploitation rates estimated in this analysis were low for Seguam Pass, Tanaga Pass and Kiska Island (<5%) and little danger of localized depletion of prey is expected. However, higher exploitation rates at Amchitka (50%) make this area susceptible to localized depletion during the time of the fishery in the area outside the trawl exclusion zone (NMFS 2006b; Ortiz and Logerwell 2010).” [BiOp, 236]

Uncertainty associated with the estimates of exploitation rates is large, but the BiOp did not consider any uncertainty. Table 4.2 has the coefficients of variation for estimates of Atka mackerel biomass from the periodic surveys conducted by NMFS. If catch in an area is considered known without error as to amount and location, the CVs for estimated exploitation rates are the same as those for estimated biomass. Coefficients of variation ranged from 15% to 40% even when the western and central Aleutian Islands were taken as a whole (Areas 541–543 combined). The estimated exploitation rate of 50% for Amchitka given in Ortiz and Logerwell (2010) have a 95% confidence interval from 23% to 77% based on the specified precision for Area 542 (median CV of 28% in Table 4.2). That confidence interval should be larger because only a fraction of Area 542 is considered in the estimate. Dividing the survey into the three areas greatly worsens the precision. The precision in estimated biomass indicated in Table 4.2 is insufficient to detect differences across Areas 541–543 collectively when on average 25% of estimated biomass of Atka mackerel is in Area 541, 40% in 542, and 35% in 543 (calculated from Table 16.8 in Lowe et al. 2010). Further dividing each area into RCAs makes the problem worse.

Inferences drawn in the BiOp are supposed to be “*based on the best scientific information available*”. As such, the CVs of the estimated biomass are a crucial part of the “*best scientific information available*”, but were ignored relative to spatial overlap.

Table 4.2.—Coefficients of variation for estimates of Atka mackerel biomass from surveys in the Aleutian Islands (statistics from Table 16.8 in Lowe *et al.* 2010).

Year	All Areas	Area 543	Area 542	Area 541
1991	15%	18%	18%	83%
1994	33%	55%	48%	44%
1997	29%	56%	34%	68%
2002	20%	31%	24%	58%
2004	17%	24%	34%	33%
2006	28%	35%	24%	55%
2010	40%	59%	28%	75%

Exposure of Habitat to Fishing: Decision Points NOT in the BiOp

As stated above, the range of decision points listed under “EXPOSURE (of) Habitat” in Figure 4.1 was incomplete. They should have included consideration of fishing power through an expression of catch rates. The BiOp touched on this matter, but went no further than stating:

“However, the critical link between fisheries removals (time, rate, location, etc.) and the effects on Steller sea lions is poorly understood and we cannot determine the relationship between these catch rates and the impacts on prey except that higher catch rates would be more likely to result in localized depletions (or prey field effects) as described by NMFS (2006b).” [BiOp, 240]

The corollary to this quote is that *lower* catch rates would be *less* likely to result in localized depletions. Regardless of the extent of overlap in time, space, size, depth, size of prey, or compression of fisheries, a fishery should not be found to “*potentially affect SSLs*” if catch rates are extremely low. This should have been considered in the BiOp.

Estimated harvest rates of fisheries for pollock and Atka mackerel are small (1% and 8% annually, Table 4.3), however the median estimated annual catch rate of Pacific cod in the western and central Aleutian Islands is 34%. By any reasonable standard, the estimated catch rate for pollock is too low to warrant concern, while the estimated catch rate for Pacific cod is sufficiently high to do so. The catch rate for Atka mackerel is also low.

Uncertainty in biomass estimates for Atka mackerel (Table 4.2) makes it difficult to apportion biomass of fish available to sea lions in critical habitat. However, this uncertainty does not mean that catch rates for Atka mackerel must therefore be higher. An 8% catch rate with a CV of 28% (the median CV in Table 4.2) produces a 95% confidence interval on the catch rate of 4% to 13%.

A second missing decision point (from Figure 4.1) concerns the biomass of the prey species. Biomass was not deemed a decision point, although “Changes in Prey Biomass in AA” is listed in the schematic as a HABITAT RESPONSE.

Along with catch rates in fisheries, biomass of prey species relates to the availability of prey. A casual inspection of biomass estimates of prey (Figure 4.4) shows that catch rates for Atka mackerel and Pacific cod may not be as troublesome to Steller sea lions as they might first appear. Recent biomass estimates indicate there are just over 800 thousand mt of Atka mackerel in the western and central Aleutians, which means that a catch rate of 8% would leave a large number of fish for sea lions. In contrast, the 34% estimated median catch rate for Pacific cod is on a much smaller biomass, meaning that catches of that species would have small effects on the prey field for sea lions. Stopping fishing for Pacific cod might double the biomass of Pacific cod in the Areas 542–543, but would not appreciably increase the amount of available prey for sea lions. In short, sea lions likely eat more Atka mackerel because it is more available than Pacific cod or walleye pollock in the western and central Aleutians.

Consideration of area-wide biomass and catch rates of important sea lion prey species should have been included in the decision point analysis to provide perspective on whether there is a

Table 4.3.—Estimated “harvest” rates for areas 541–3 combined calculated as catch divided by estimated biomass both in mt (data taken from [BiOp, Table 5.2]).

	Pollock	Pacific cod	Atka mackerel
1999	1%	23%	11%
2000	1%	34%	10%
2001	1%	33%	12%
2002	1%	34%	8%
2003	1%	35%	8%
2004	1%	31%	7%
2005	1%	26%	8%
2006	1%	30%	7%
2007	2%	43%	7%
2008	1%	40%	7%
2009	1%	35%	7%
Median	1%	34%	8%

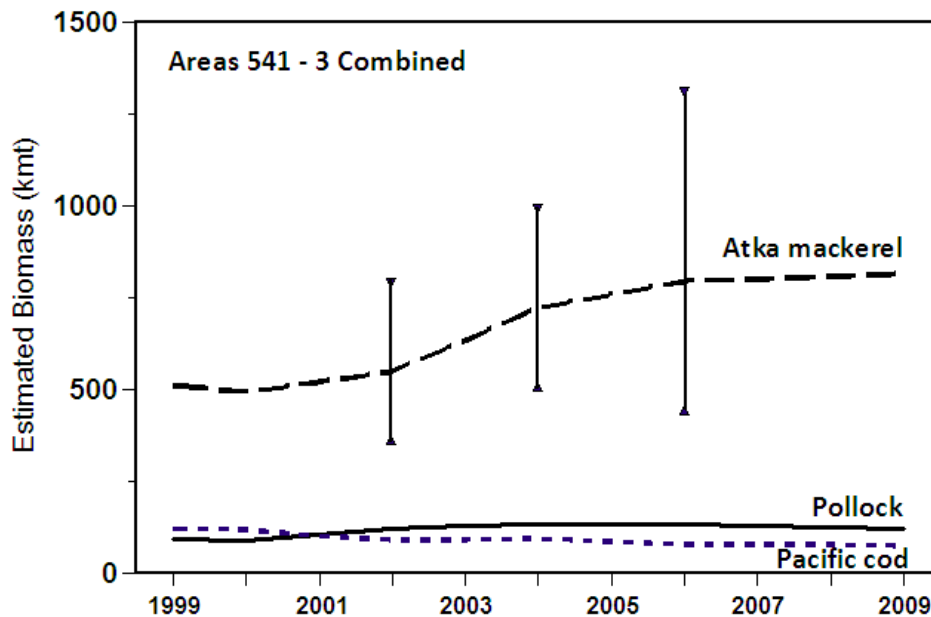


Figure 4.4—Estimated biomass of Atka mackerel, Pacific cod, and pollock in areas 541 – 543 combined with 95% confidence intervals from surveys for Atka mackerel. Data taken from [BiOp, Table 5.2] and Lowe *et al.* (2010).

relationship between fisheries and declines in sea lion numbers. Shortages of prey caused by fisheries should have been readily observed in the fish stock assessments, fishery catches and sea lion physiology and behaviors if they had indeed occurred. However, the BiOp never considered the possibility that fishing may have had nothing to do with the decline of sea lions. The BiOp also does not recognize the significance of the finding of Fadely *et al.* (2010) that there is a much higher biomass of fish available to Steller sea lions in the Aleutian Islands than in the Gulf of Alaska where sea lions are recovering. None of these scientific findings are consistent with a hypothesis of fishery-driven nutritional stress.

Food Web Dynamics

Paralleling the pathway labeled “Direct”, Figure 4.1 contains a second pathway labeled “Indirect” that passes through a point labeled “Food Web Dynamics ALL TACs”. No decision points are indicated along this second pathway. How this pathway explicitly fits into a “nutritional stress” hypothesis is unclear in the schematic, but a hint is contained in the following:

“Fisheries can also have indirect biological effects that occur when fisheries remove large numbers of target species and non-target species (incidental catch or bycatch) from a marine ecosystem. These removals can change the composition of the fish community with associated effects on the distribution and abundance of prey organisms. Fishery removals compete with other consumers that depend on target organisms for food. These biological interactions are generally termed cascade effects and competition. The ultimate impact to Steller sea lions from these types of modification to their prey resources could potentially include either acute or chronic nutritional stress (Trites and Donnelly 2003; see Section 3.1.14).” [BiOp, 198 – 9]

We presume that this pathway represents a more comprehensive, multispecies look at how fisheries might affect sea lions through perturbation of the ecosystem. This pathway is the route taken using food-web, predator-prey, and ecosystem models. The BiOp does not explain why no decision points were involved in this pathway.

The argument that the fishery for Pacific cod has meaningfully reduced the prey field for Steller sea lions is undercut by the results of simulations of multispecies models reported in the BiOp. Virtual fishing in a virtual GOA was stopped in simulations using an “*extended dynamic food-web model based in part on Ecopath with Ecosim of Christensen et al. (2005)*” (Dorn *et al.* 2005; NMFS 2006b) [BiOp, 252] as described in Sections 4.5.4.6 [BiOp, 249 – 255]. The modeling results from the GOA was proffered as a surrogate for the situation in the BSAI area :

- 1) *“Overall, the clear effects of fishing on the ecosystem are apparent only for top predators which are directly exploited, either as target species or as bycatch [species such as halibut or Pacific cod]”; [BiOp, 253]*
- 2) *“The effect of ceasing fishing (on all species) on arrowtooth flounder results in a definite downward trend for arrowtooth”; [BiOp, 253]*

- 3) “Under the no fishing scenario, while pollock increase between 5-10% for the first few years of the simulation (2006-2009), this is followed by a decrease back to the level of the status quo scenario”; [BiOp, 253] and
- 4) “For Steller sea lions, the model predicts that the cessation of fishing would cause Steller sea lions to increase in biomass (50% confidence intervals [sic] is between 2-10% increase). It is important to note that this effect, similar to that for pollock, is also dampened over time.” [BiOp, 253]

Putting aside the BiOp’s reliance on a 50% confidence interval to indicate an “increase” in the biomass of sea lions, results indicate that a cessation of fishing would not affect the prey field sufficiently to produce anything but a small and transient increase in sea lion biomass.

A similar set of simulations from the food-web model by Aydin (2010) aimed more specifically at the fisheries and fish stocks of the western and central Aleutian Islands yielded essentially the same results for the effect on Pacific cod—*i.e.*, no meaningful change occurred in the sea lion biomass from a reduction in fishing for Pacific cod (Figure 4.5). This modeling was conducted

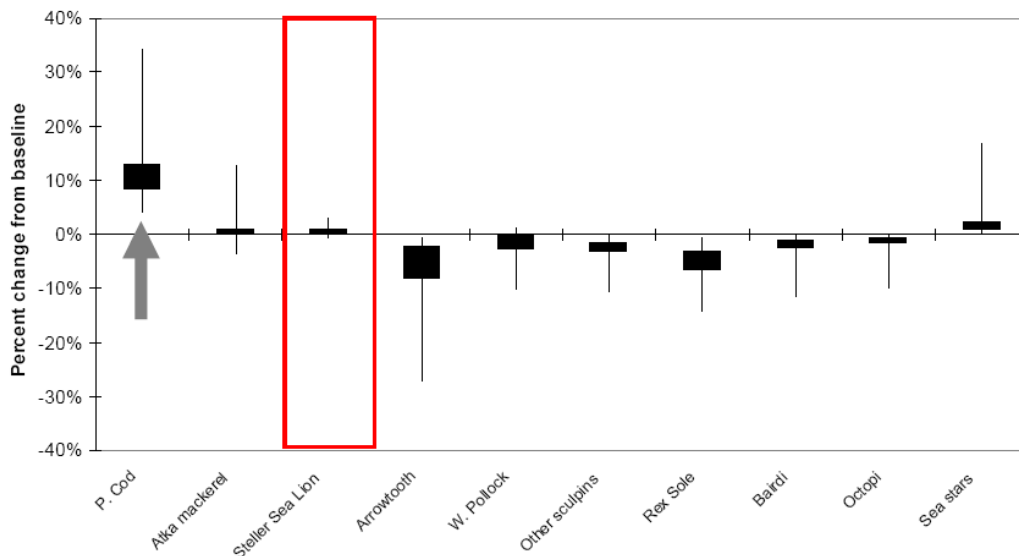


Figure 4.5.—“The effects on the Aleutian Islands food web model (percent change of biomass from baseline) of reducing Pacific cod mortality by 10% (manipulated species shown by arrow). Only selected species are shown. Bar and lines show 50% and 95% of results obtained from 500 ecosystems drawn from parameter distributions based on uncertainty in input parameters of biomass, production rates, consumption rates, and diets, as described in Aydin et al. (2007) (Source: Aydin 2010)”. [Figure 4.3 is BiOp, Figure 8.6]

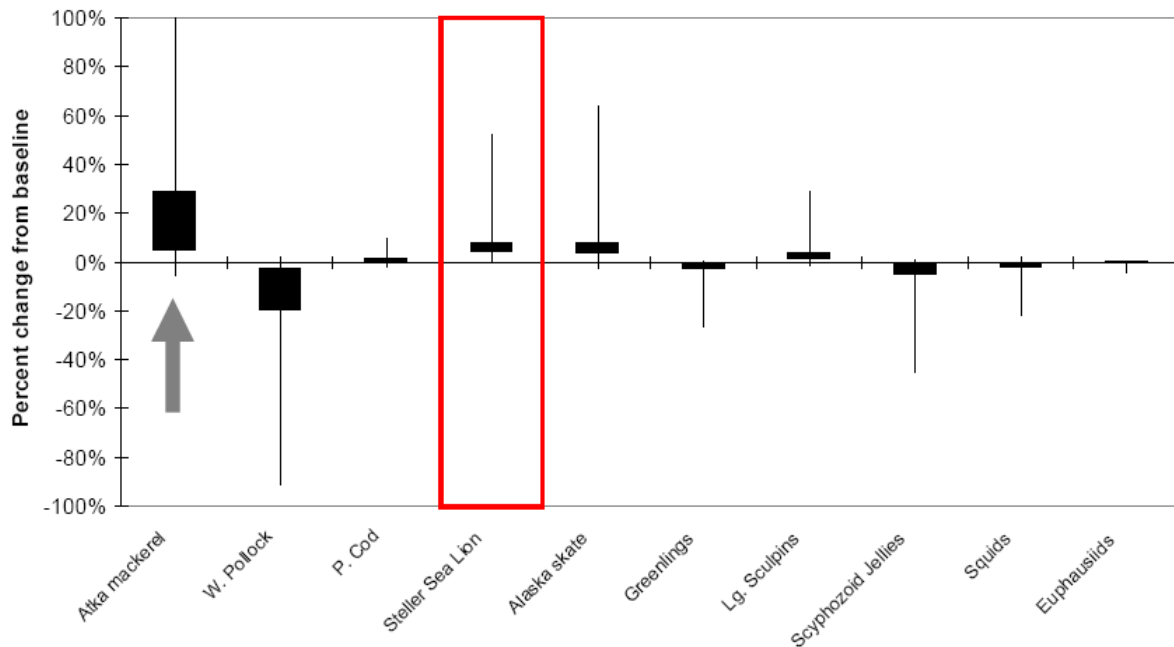


Figure 4.6.—“The effects on the Aleutian Islands food web model (percent change of biomass from baseline) of reducing Atka mackerel mortality by 10% (manipulated species shown by arrow). Only selected species are shown. Bars and lines show 50% and 95% of results obtained from 500 ecosystems drawn from parameter distributions based on uncertainty in input parameters of biomass, production rates, consumption rates, and diets, as described in Aydin *et al.* (2007).” (Figure 4.4 is Figure 7 in Aydin 2010).

to gauge the effectiveness of RPAs to meet recovery goals, and is shown as a graph [BiOp, Figure 8.6] followed by the statement:

*“Overall, the model predicts that declines in Atka mackerel fishing throughout the Aleutian Islands would lead to increases in prey supply for Steller sea lions and that a simulated closure of Area 543 to Atka mackerel fishing would show similar results. However, the model predictions are mixed on the effects of reducing Pacific cod fishing in Area 543, with limited apparent effects on the total Steller sea lion food supply (Aydin *et al.* 2007; Aydin 2010).”* [BiOp, 362]

Figures 4.5 and 4.6 show the effects on other species of reducing *all mortality* on Pacific cod or Atka mackerel by *10 percentage points*, and is not confined to just reducing fishing mortality. Thus the models show that reducing the median harvest rate for Pacific cod from 34% (Table 4.3) to 24% would have no meaningful effect on the biomass of Steller sea lions (Figure 4.5). The predictions of the models do not support the conclusion of the BiOp that the effect of reducing mortality on Pacific cod are “mixed”.

No materials other than the simulation results in Figure 4.6 were presented to support the statement “that declines in Atka mackerel fishing throughout the Aleutian Islands would lead to

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increases in prey supply for Steller sea lions” [BiOp, 362]. These simulations (Figure 7 from Aydin 2010 — our Figure 4.6) were run until the virtual biomasses reached equilibrium, but the time to reach equilibrium was not specified (Aydin 2010).

Although the food-web and ecosystem models implied that fishing posed a risk to Steller sea lions (at least from fishing for Atka mackerel), the models were essentially rejected in the BiOp:

“... NMFS examined the results of both single-species and multispecies models of reduced Atka mackerel and Pacific cod fishing mortality in the Aleutian Islands overall and in Area 543. ... Trade-offs must be made between the advantage of greater biological realism via multispecies information and the disadvantage of increased uncertainty due to additional model complexity Here we note that uncertainties inherent with the assumptions of single-species approaches become magnified in multispecies models. Therefore, NMFS believes that given the information available, it is premature to add more assumptions to the models predicting predator-prey responses and has relied on the results of the single species models to a greater extent than the multispecies models in predicting the effects of the RPA.” [BiOp, 362]

Using food-web and ecosystem models in this way bypassed the decision points in the second schematic in Figure 4.2 of the fishery-driven nutritional stress hypothesis.

Results of Nutritional Stress

The process of how NMFS determined if sea lion populations exposed to the effects of fishing were suffering nutritional stress contained many decision points as described in Figure 4.2. The first decision point in the process (schematic) concerned an increase in foraging effort by Steller sea lions, and appears to end in a finding of nutritional stress regardless of the decision. This decision point is also unanswerable, at least for adult sea lions:

“Given that no measurements have been made for adult Steller sea lions in the Alaska portion of the western DPS since the 1990s (other than numbers of individuals from population counts), changes in body condition, reproductive success, and foraging parameters that would be direct indicators of acute or chronic nutritional stress are currently unknown for adults, except for those estimated (predicted, our addition) by demographic models (York 2003, Fay 2004; Fay and Punt 2006; Holmes et al. 2007).” [BiOp, 118]

The second decision point asks whether there are “*Sufficient (prey) Resources for Survival?*” or Sufficient “*Resources for All Functions?*”. A decision of “no” to either or both decision points leads to the conclusion that sea lion populations are suffering from nutritional stress, either chronic alone, or acute and chronic nutritional stress at the same time. The 17 conditions in the box with the heading NUTRITIONAL STRESS comprise a catalogue of expected observations if the sea lion populations are suffering from chronic nutritional stress.

Central to assessing whether prey resources are sufficient for sea lions to survive or complete all of their functions is knowing what are the nutritional needs of sea lions and how much prey is

available to them. This ultimately requires calculating the ratio of forage fish available per sea lion.

Forage Ratios

The BiOp provides considerable discussion about the importance of prey abundance and distribution to the reproduction and survival of Steller sea lions [BiOp, 291-292]. However, NMFS found no shortage of prey when the amount of prey within RCAs was compared with the amount of food that sea lions required (Fadely *et al.* 2010). The BiOp notes that there was more than 40 times more prey available than sea lions required in RCA 1. The BiOp also notes that

“Ortiz and Logerwell (2010) reported Atka mackerel production alone was sufficient to meet SSL consumption requirements at Seguam, Tanaga and Kiska trawl exclusion zones, yet these are areas where the numbers of sea lions in the last decade have declined.” [BiOp, 291]

These and other findings contained in Fadely *et al.* (2010) and Ortiz and Logerwell (2010) are inconsistent with the view that the density of prey was reduced by fishing and is insufficient to meet the needs of sea lions (*i.e.*, fishery-driven nutritional stress). However, the BiOp does not appear to give these findings any credence. Nor does the BiOp consider that the high abundance of groundfish relative to the needs of sea lions is consistent with the “*junk food*” hypothesis (*i.e.*, environmentally-driven nutritional stress addressed in our Chapter 5).

Failure to find any indication of fishery-driven nutritional stress in the forage ratio assessments leads the BiOp to conclude that

“Given the long-standing decline in abundance of SSL in RCA 1 (Area 543, western Aleutian Islands), it is clear that a high forage ratio alone is not sufficient for understanding trends in abundance”. [BiOp, 291]

This statement in the context of a finding of JAM is evidence of *confirmation bias* — *i.e.*, a willingness of the BiOp to reject observations that did not support a finding of jeopardy, and a reluctance of the BiOp to use the available data and scientific findings to test the hypothesis that fishing negatively affected Steller sea lions.

The BiOp presents updated forage ratio estimates for Steller sea lions (*i.e.*, the biomass of groundfish available to sea lions divided by the annual amount consumed by sea lions) (Table 4.4). Two things stand out from these comparisons of forage ratios. The first is that there is an inverse relationship between forage ratios and rates of sea lion declines (*i.e.*, forage ratios dropped as sea lion declines stopped or reversed in the Gulf of Alaska and Eastern Bering Sea while forage ratios increased in the Aleutians where sea lions have been declining). The second notable thing about the comparisons across regions is that the forage ratio in the Aleutian Islands (*i.e.*, where there is 8 times more groundfish than sea lions need) is now double that of the Eastern Bering Sea (4 times more groundfish) and is even higher compared to the ratio of fish available to sea lions in the Gulf of Alaska (which only has 3 times more groundfish than

Table 4.4.—Forage ratios (forage biomass available divided by annual consumption by sea lions) as reported in NMFS 2001 and 2003 (see Fadely *et al.* 2010). Forage biomass was based on survey estimates of all groundfish species, as reported in Fadely *et al.* (2010). Past forage ratios are based on data from surveys between 1997 and 2002; current forage ratios are based on from surveys between 2004 and 2010). [BiOp, 298, in-text table]

	Areas 543, 542, 541	Eastern Bering Sea	Gulf of Alaska
Past (all area)	19	322	26
Current (all area)	26	201	24
Past (CH only)	5	14	4
Current (CH only)	8	4	3

needed by the sea lions). The BiOp nevertheless states that

“... the amount of forage biomass in critical habitat alone in areas 543, 542, and 541 appears to be insufficient by itself to support efficient foraging (i.e., relative to forage ratios of 20-50; see above)” [BiOp, 299],

but fails to recognize that critical habitat forage ratios are much lower than 20-50 in the Eastern Bering Sea and Gulf of Alaska where sea lions are recovering and prey abundance is presumed to be sufficient to support efficient foraging.

The estimates of forage ratios (Fadely *et al.* 2010) suggest that sea lion populations have been doing poorest where the relative abundance of groundfish has been the highest. The regional comparisons of forage ratios do not support the fishery-driven nutritional stress hypothesis, but are consistent with environmentally-driven nutritional stress (see our Chapter 5).

Sigler *et al.* (2009) compared the amounts of prey available to the numbers of Steller sea lions present and concluded that a standing biomass of 500 to 1700 t of prey in a non-breeding area can attract and sustain about 500 sea lions. These estimates (reported and discussed on [BiOp, 297]) apply to Southeast Alaska where the sea lion population grew and has been considered healthy. Sigler *et al.* (2009) estimated that the biomass needed by 500 sea lions ranged from 500-1700 t because of the energetic difference between species of fish. In other words, 500 sea lions could be supported by as little as 500 t of high energy fish such as herring and eulachon (500 t at 10 kJg⁻¹) or by as much as 1700 t of low energy fish such as pollock and hake (1700 t at 3 kJg⁻¹). Assuming the average sea lion requires 79,464 kJ per day, the 500 t of high energy fish would provide 500 sea lions with 63,000 daily rations, and the 1700 t of low energy fish could provide 500 sea lions with about 19,000 daily rations. This translates into an average daily density of 1 ton of high-energy forage fish or 3.4 tons of low-energy fish per sea lion to support the healthy and growing population of sea lions. The BiOp converted these daily estimates from Sigler *et al.* (2009) into a daily forage ratio of 126 (*i.e.*, the biomass of groundfish available to sea lions divided by the daily amount consumed by sea lions). The BiOp thus concluded there was 126 times more prey available than sea lions needed in Southeast Alaska, but did not recognize that this translates into a annual forage ratio of just 0.35, which is significantly lower

Table 4.5.—Forage ratios for the Steller sea lions based solely on estimated biomass of pollock, Pacific cod, and Atka mackerel (from Fadely *et al.* 2010). [BiOp, 299]

	All groundfish (kt)	Consumption (kt/yr)	Ratio	Pollock, Pacific cod, Atka mackerel (kt)	Ratio
543	721.7	17.8	40.6	465.5	26.1
542	702.3	53.0	13.2	285.3	5.4
541	900.0	59.5	15.1	267.2	4.5

than any of the forage ratios calculated for the western population (see Page 298 and Fadely *et al.* 2010)

The BiOp also contains estimates of the ratio of biomass of pollock, Pacific cod, and Atka mackerel present relative to sea lion needs by fishery management areas in the central and western Aleutian Islands (Table 4.5). Comparing these estimates (by Areas 541, 542 and 543) with the rates of decline contained in the accompanying text shows the same relationship seen at the broader regional scale for all species of groundfish (Table 4.4). This relationship is not discussed in the BiOp and shows that management areas with the highest forage fish ratios had the highest rates of sea lion decline (*i.e.*, non-pups in Area 543 declined at 6.83% per year in the presence of 26.1 times more groundfish than needed to meet their needs; while sea lions in Area 542 declined more slowly at 2.33% annually with the forage ratio was only 5.4; and Area 541 declined at 0.39% with a ratio of just 4.5). These data suggest that population declines of Steller sea lions were associated with high relative abundances of pollock, Pacific cod and Atka mackerel.

Lack of Evidence for Fishery-driven Nutritional Stress

A list of conditions (emaciated pups, reduced body size, etc.) that should occur and be observed when Steller sea lions are undergoing acute and especially chronic stress are provided in Figure 4.2 in the box labeled NUTRITIONAL STRESS. The BiOp also contains, but does not reference its own table of observations from the WDPS [BiOp, Table 3.17] that concern most of the conditions in Figure 4.2. Our Table 4.6 melds the conditions listed in Figure 4.2 into the BiOp's Table 3.17. Thus the 17 conditions identified by the BiOp (see box in Figure 4.2) can be combined and reduced to 8 general conditions that indicate nutritional stress (*i.e.*, reduced body size, reduced reproduction, reduced survival, etc.).

The data compiled by NMFS and shown in Table 4.6 lead to the conclusion that sea lions in the WDPS are *not currently suffering from nutritional stress*, at least not the kind of nutritional stress caused by fishing. Of the four general conditions for which there is any information for the years 2000–2004, three (emaciation, reduced body size, and reduced survival) can be answered with “no”, meaning:

Table 4.6.—“Data gaps for assessing potential biological manifestations of nutritional stress in the western DPS of Steller sea lions. Evidence is based on a comparison with the previous decade (H=historical) or with the eastern DPS (G=geographic). Y = Yes, data are available to make a comparison and the effect was indicated; N=No, data are available to make a comparison but the effect was opposite to that indicated; U=Unknown, no data are available; U*=Unknown, data available but not analyzed.” [BiOp, Table 3.17]. Some cells are boxed and others shaded to further contrast different outcomes.

General Conditions of Nutritional Stress	Potential Biological Effects [BiOp, Table 3.17]	1980s	1990s	2000–2004
Emaciation	More emaciated pups (< 4 wks)	U	U*	N(H)
	More emaciated pups (> 4 wks)	U	U	U
	More emaciated juveniles	U	N(H,G)	U
	More emaciated adults	U	N(H,G)	U
Reduced body size	Reduced adult body size	Y(H)	U	U
	Reduced juvenile body size	Y(H)	U*	U
	Reduced pup body size	U	N(G),U*(H)	N(H)
	Reduced birth weight	N or U?	U	U
	Reduced pup weight	?	N(G),U*(H)	N(H)
	Reduced growth rate	Y(H)	N(G)	N(H)
	Decreased weaning size	U	U	U
	Traditional ecological knowledge re. body size	?	U*	U*
Reduced survival	Reduced pup survival	? or U	U*	N(H)
	Reduced pup survival (to 4 wks)	U*	U*	U
	Reduced juvenile survival	Y(H)	Y	N(H)
	Reduced adult survival	Y(H)	N	N(H)
	Reduced overall survival	Y(H)	Y(H,G)	N(H)
	Reduced non-pup counts	Y(H)	Y(H)	N(H)
Reduced reproduction	Reduced birth rates	Y(H)	Y(H)	Y(H)
	Reduced pup counts	Y(H)	Y(H)	N(H)
	Increased abortion rates	Y(H)	U	U
	Delayed sexual maturity	U	U	U
Changes in physiology	Change in pup blood chemistry (increased fasting)	U	N(G)	U
	Change in juvenile blood chemistry (increased fasting)	U	U*	U
	Change in metabolic rate	U	U	U
	Decreased body condition (adult females on rookeries)	U	U*(N(G))	U
	Increased maternal investment	?	?	?
Changes in behavior	Altered age of weaning	U	U*(G)	U*
	Reduced adult perinatal fast	U	N(G)	U
	Longer foraging trip duration	U	N(G)	U*
Increased disease	Increased incidence of disease (haptoglobin)	U	U*	U
	Increased incidence of disease	U	N(G)	
Increased predation	Increased susceptibility to predation	U	U	U

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- pups were not emaciated,
- body size of pups was not reduced;
- pup were not underweight;
- body growth rates were not lower
- survival of pups, juveniles and adults had increased compared to past decades;
- numbers of juveniles and adults had increased; and
- numbers of pups born had also risen.

Evidence was lacking on four other conditions for 2000–2004 (changes in physiology, changes in behavior, increased disease, and increased predation) because data on each effect were not available or had not been analyzed.

The only question answered by “yes” for years 2000–2004 was associated with “*reduced reproduction*”. Although the increase in total numbers of pups born in the WDPS suggests that reproduction is no longer reduced, estimated birth rates (based on the mathematical models of Holmes *et al.* 2007 – see following discussion) suggest that a smaller proportion of females were giving birth than in past decades.

Birth Rates

The BiOp concludes that the decline of the western population of Steller sea lions was due to poor survival of juvenile sea lions in the 1980s and later by reproductive failure during the 1990s and 2000s. In support of this conclusion, the BiOp notes that

“an examination of reproduction and growth yields considerable evidence which suggests that while declines in the western Steller sea lion population in the 1980s were associated with decreased juvenile survival, the slower declines of the 1990s and the lack of a robust rate of increase in abundance in the 2000s in this population are associated with decreased reproductive success at least in some areas”. [BiOp, 92]

Similarly, the BiOp reports that

“In this last decade, the available information on birth and death rates indicates that adult and juvenile survival rates are similar to those pre-decline, but that natality has declined on the order of 30% relative to the predecline era.” [BiOp; xxvii, 341]

The BiOp further states that the central Aleutian Islands sub-region “*experienced a 36% decrease in natality over the past three decades*” [BiOp; xxix, 341] and that

“the 1990s data suggest that ... pregnant females with and without pups may have experienced chronic nutritional stress after leaving the rookery, as evidenced by decreased pregnancy rates of lactating females and decreased natality rates overall.” [BiOp, 118–119]

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The BiOp also notes that “*pup to non-pup ratios based on data collected in 2009 suggest that natality rates of the western DPS are lower than those in southeast Alaska (DeMaster 2009)*” [BiOp, xxix] with the lowest ratios occurring in the western Aleutian Island (Table 3.6 pup to adult female ratios in BiOp, and Figure 8 in DeMaster 2009). According to the BiOp,

“the most reasonable explanation for the pattern of natality in the western DPS relative to the eastern DPS is that portions of the western DPS may be nutritionally stressed.”
[BiOp, xxix]

In many respects, the BiOp overstates its confidence in the NMFS interpretation of the pup ratio data and their readiness to inappropriately extrapolate model results to regions where natality estimates have never been estimated. For example, there are no data to support the assertion that the central Aleutian Islands “*experienced a 36% decrease in natality over the past three decades*” [BiOp, xxix]. This value (36%) appears to be taken out of context from the mathematical models produced by Holmes *et al.* (2007) for the Central Gulf of Alaska. The model predictions for the Central Gulf cannot be assumed to apply to all regions of Alaska. There are also no data to support the claim that “*pup to non-pup ratios are an indicator of reproductive rates (or natality) in sea lion populations.*” [BiOp; xxviii, 341].

Wildly different pup ratios can be generated for populations that have equal birth rates by simple virtue of there being regional or interannual differences in the forage base and time that adult females spend foraging. For example, longer feeding trips were recorded in Southeast Alaska compared to the Gulf of Alaska in the 1990s (Andrews *et al.* 2002; Milette and Trites 2003). Longer feeding trips will result in fewer adult females being on shore when counted, which would yield a higher ratio of pups to adult females. Such a difference in feeding trips would lead to the conclusion that birth rates were higher in Southeast Alaska even if birth rates were identical in both regions. Equally meaningless pup ratios can be obtained by comparing pups born in one year (*e.g.*, 2009) with adults present in different breeding season (*e.g.*, 2008)—as done by NMFS in [BiOp, Table 3.6].

Overall, there are relatively few data to infer natality rates of Steller sea lions in Alaska. The ratios of pups to adult females [BiOp, Table 3.6] or non-pups (DeMaster 2009) are not reliable indicators of reproductive rates because the variables that affect the number of juveniles and adult sea lions onshore are a function of too many variables besides birth rates that are unlikely to stay constant between years or across sites (*i.e.*, weather conditions, foraging conditions, length of feeding trips, availability of alternative resting sites for non-reproducing animals, age at weaning, time of day, tide height, duration of the perinatal period, and day counted relative to the mean date of birth). Thus the ratios of pups to counts of other age classes as presented in the BiOp are likely meaningless measures. This is not to say that natality was not lower where sea lion populations declined—only that the differences in ratios are unlikely to identify areas with higher or lower natality rates relative to one another.

The little natality data that are available for Steller sea lions comes largely from the Central Gulf of Alaska. Reproductive tracts taken from small numbers of female sea lions shot in the 1970s (n=46) and 1980s (n=62) showed that pregnancy rates were lower in late gestation than in early gestation (when 95-100% started out pregnant), and that the near-term pregnancy rate was just

67% in the 1970s, and 55% in the 1980s (Pitcher *et al.* 1998). This difference in effective birth rates was not statistically significant ($P=0.34$), but was consistent with the population trends in this region (Pitcher *et al.* 1998). Pitcher *et al.* (1998) also reported that late gestation pregnancy rates of females still nursing pups or juveniles were only 30% in the 1980s compared to 63% in the 1970s. Again, these differences were not statistically significant ($P=0.06$), but imply that females may have been keeping their pups for an extra year rather than weaning them and having a new pup if feeding conditions were not optimal for juvenile survival. No other shot samples have been collected since the 1980s to estimate the natality rates of Steller sea lions.

The BiOp reports that

“Comparatively low birth rates for females from the western DPS from mid-1970s to mid-1980s coupled with elevated embryonic and fetal mortality appear to have contributed to decreased reproductive performance during the period of early decline.”
[BiOp, 339]

This confusing sentence suggests that the BiOp has confounded birth rates with pregnancy rates, and does not recognize that the drop in pregnancy rates from early gestation to late gestation reflects the loss of fetuses (Pitcher *et al.* 1998). The low birth rates reported by Pitcher *et al.* (1998) during the 1980s reflected elevated fetal mortality.

Natality rates in the Central Gulf of Alaska during the 1990s and 2000s have been inferred from mathematical models that attempted to find the best combination of birth and death rates that could explain the numbers of pups, non-pups and ratios of juveniles to adult counts in the Central Gulf of Alaska (Holmes and York 2003; Holmes *et al.* 2007). The models fit the data best when birth rates decreased steadily from 0.67 (during the 1970s) to 0.55 (during the 1980s) and to 0.43 by 2004 (Holmes *et al.* 2007). The model predicted that birth rates would have had to have fallen by 36% since the 1970s to explain the pattern of observed counts. Holmes *et al.* (2007) noted that the patterns of counts and ratios observed in the Central Gulf of Alaska were similar elsewhere in the western population, and therefore postulated that declining birth rates might also be a problem across the Gulf of Alaska and into the Aleutian Islands. However, natality rates were not estimated for these other regions.

All of the available estimates of natality (1970s, 1980s, and 1990s & 2000s) are for the Central Gulf of Alaska—with the exception of a single estimate of natality in Kenai Fjords (eastern Gulf of Alaska). Maniscalco *et al.* (2010) estimated that the birth rate at Chiswell Island was 69% from 2003-2009 based on direct observations of individually recognized sea lions. Attempts to correct for potential biases associated with direct observations suggest that the actual birth rate was lower and in the range of 52%, 54% and 62% (AFSC 2009; Holmes 2009; Johnson 2009). All of these revised estimates of natality are higher than the 43% derived by the model for 1997-2004 (Holmes *et al.* 2007), and suggest the possibility that birth rates either improved in the Gulf of Alaska or may have remained at the 1980s level estimated by Pitcher *et al.* (1998) from shot samples of adult females in the Central Gulf of Alaska. They do not support the BiOp's contention that birth rates are continuing to fall in the WDPS.

The BiOp correctly acknowledges that

“A series of critical data gaps remain regarding the determination of 1) in which parts of the range have rates of natality continued to decline, 2) whether this decline is due to reduced prey biomass, abundance, and nutritional stress, and 3) how females respond to nutritional stress in their relative energy expenditures on lactation, pregnancy and their own maintenance.” [BiOp, 118]

However, the BiOp overlooks this sober acknowledgement when making bold and sometimes incorrect statements about natality that are not supported by data or statistical significance. For example, the BiOp has a tendency to imply statistical significance when none exists — *e.g.*, *“late season pregnancy rates in lactating females declined between the 1970s (63%) and the 1980s (30%), indicating a decreased ability in females to support a fetus and successfully complete consecutive pregnancies (Pitcher et al. 1998).”* [BiOp, 92]. Similarly, the BiOp assumes that findings from one region can be applied with no justification to other regions of Alaska — *e.g.*, the central Aleutian Islands sub-region *“has experienced a 36% decrease in natality over the past three decades”* [BiOp, xxvii]. And at other times the BiOp introduces new numbers with no explanation as to their source—*“In this last decade, [sic] natality has declined on the order of 30% relative to the predecline era.”* [BiOp, 341] which differs from the 36% estimated by Holmes *et al.* (2007). Thus, the certitude with which the BiOp concludes that *“a three-decade long decline in natality in the central GOA began”* (in the 1980s) [BiOp, 278] should have been tempered with the concession that was only recognized twice in the BiOp that the decline in modeled natality may only be *“a possible decline in natality”* [BiOp, 173 and 260].

Despite the uneven way in which the BiOp treats the natality data, there is good reason to believe that a drop in birth rates is a credible explanation for the decline of Steller sea lions given that there are direct observations of lower birth rates in the 1980s and 2000s in the Gulf of Alaska compared to the 1970s (Pitcher *et al.* 1998; AFSC 2009; Holmes 2009; Johnson 2009; Maniscalco *et al.* 2010). As for a mechanism that would have caused pregnancy rates to fall, the BiOp discusses how reduction in prey availability can reduce natality of pinnipeds (see [BiOp; 199, 256 and 257]), which leads by extension to the implicit conclusion that declining birth rates of sea lions must reflect a reduction in prey caused by fishing. However, a reduction in quantity of prey is not supported by any of the metrics in sea lion behavior and maternal care that are consistent with starvation-like food shortages. This appears to be recognized in the BiOp when stating that

“Age-structured models fit to pup and non-pup counts suggest that this decline in reproductive success continued through the 1990s and into the 2000s (Holmes et al. 2007), but there is no comparable direct evidence that acute nutritional stress was responsible for the continued decline of the western DPS during the 1990s.” [BiOp, 339]

As for an alternative to the fishing explanation for the reduced birth rates, the BiOp does not discuss the possibility that a change in the quality of diet could also reduce birth rates by reducing the blubber layer and condition of females (*i.e.*, blubber layers would be reduced if mothers consumed more high-protein fish such as pollock and ate less high-lipid fish such as

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sand lance as is believed to have occurred since the 1970s). The BiOp appeared to be cognizant that quality could be as important as quantity of prey when they wrote

“There is evidence that natality has decreased by 36% in the past three decades in at least part of the central GOA, possibly due to nutritional stress from a reduction in quality or quantity of available prey (Holmes et al. 2007).” [BiOp, 375]

However, the BiOp gave no further consideration to how a change in quality of diet could explain the decline of birth rates. Thus the BiOp was not thorough in examining the mechanisms that could explain a drop in natality rates.

A proverb says “a chain is only as strong as its weakest link.” But in terms of the probability involved in confirming a scientific hypothesis, a chain of reasoning may be much weaker than its weakest link. The more uncertain links in a chain of reasoning, the greater the cumulative uncertainty associated with the entire chain. The BiOp presents a long chain of reasoning for the fisheries-induced nutritional stress hypothesis. As discussed above, many of the links in this chain are weak. The full chain of reasoning is weaker than any of the individual links.

Summary

In our judgment, the fishery-driven, nutritional stress hypothesis proffered by NMFS as an explanation for population declines of Steller sea lions in the western and central Aleutian Islands should be scientifically rejected. We base our conclusion using the process and conditions specified in the BiOp for determining the risk of exposure and subsequent nutritional stress.

The available data and analyses indicate that harvest rates of Atka mackerel were too low and the reliance on a small population of Pacific cod was too small for the fishery to cause nutritional stress in sea lions under current conditions. Modeling efforts by NMFS support this observation, especially the lack of effect of the fishery for Pacific cod on sea lion biomass. The BiOp failed to show spatial overlap between catches in fisheries and diets of sea lions, and hence local depletion of prey. Other dimensions of overlap (depth, size of prey, and time of fishing) were listed, but not investigated in the BiOp.

Arguments presented in the BiOp in favor of sea lions experiencing nutritional stress caused by a lack of groundfish are not convincing. Forage ratios of groundfish to sea lions present were higher in the western and central Aleutians than in regions where sea lions are recovering—thereby indicating a quantity of food area-wide sufficient for sea lions to avoid nutritional stress. To conclude otherwise would require explaining how sea lions in the eastern Bering Sea and the GOA show no signs of nutritional stress with forage ratios in critical habitat smaller than those in the western and central Aleutian Islands.

Considering the compelling evidence that the amounts of prey are *sufficient* to support sea lions in the western and central Aleutian Islands specifically, and for the WDPS in general, it should not be surprising that direct evidence for nutritional stress *could not be found* as posited. Two

“yes” decisions at the only two operable decision points of the process laid out in Figure 4.2 should have ended in a decision of “*No Nutritional Stress*”.

The lack of scientific evidence in support of the fishery-driven nutritional stress hypothesis in the BiOp is consistent with the meta-analysis of statistical studies of fisheries and sea lion data described in Chapter 3. No statistically significant *negative* associations between fisheries statistics and sea lion demographics occurred in the last 10–20 years suggest there is also unlikely to be other scientific evidence to support the fishery-driven nutritional stress hypothesis. And indeed, little evidence has been found.

5. ALTERNATIVE HYPOTHESES FOR CAUSES OF THE STELLER SEA LION DECLINE

The fishery-driven nutritional stress hypothesis posited in the BiOp in which groundfish fisheries in the BSAI management area negatively effect recovery of Steller sea lions of the WDPS is not the only hypothesis that has been proposed to explain a decline in sea lion numbers. Our analyses in Chapters 3 and 4 show that a fishery-driven nutritional stress hypothesis, or any hypothesis that involves fishing as an explanation for recent declines in sea lion numbers is highly improbable. Two leading alternative explanations for the perceived lack of recovery of the WDPS are what the BiOp refers to as the “*Junk Food Hypothesis*”[BiOp, 115] and the “*killer whale predation*” hypothesis.

The “Junk Food” Hypothesis

Change in the climate or a switch in environmental regimes in the BSAI area would affect the recovery of sea lions according to the “junk-food” hypothesis without any need to involve fisheries. This hypothesis can be paraphrased as:

- (1) an oceanic climate regime shift changed the composition of species available for sea lions to eat;
- (2) this shifted the prey field from one dominated by high-energy species to one dominated by low-energy species;
- (3) weaned pups cannot survive on low-energy prey, and stay with their mothers for an extra one or two years until they are big enough to eat low-energy prey on their own; and
- (4) because pups suckle longer, fewer pups are born and the sea lion population declines.

Plenty of food would be available under the “*junk-food*” hypothesis, just the wrong kind of food. Fewer and shorter foraging trips would be needed to fill stomachs, but some segments of the population would still be undernourished. Adult sea lions, with their lower per capita metabolic demands and relatively larger stomachs, would be adequately nourished. But pups and young juveniles have much higher relative metabolic demands for growth and have smaller stomachs than adults who no longer need energy to grow. As compensation, pups would suckle years longer on a diet of energy-rich milk. During this extended period of suckling, mothers would forgo or abort pregnancy with the result that fewer pups would be born (see Rosen and Trites 2000, 2004; Trites *et al.* 2006).

Considerable text (Sections 4.1.1-6, 4.2, 3.1.1.4.3) is presented in the BiOp supporting the possibility that regime changes in the BSAI ecosystem could have affected nutrition of sea lions. However, most of the discussion presented background information relative to alternative hypotheses concerning vital rates, and was not used to judge whether the “*junk-food*” hypothesis can be excluded as the cause of the current situation in the western and central Aleutian Islands.

Table 5.1.–Frequency of occurrence of prey in percent of scats collected from 1999 – 2005 at rookeries and haul outs used by sea lions in the western and central Aleutian Islands (Areas 541 – 543) and in the eastern Aleutian Islands ([BiOp, Table 3.16]; NMFS 2006b)

Region	Central & Western Aleutians		Eastern Aleutians	
Season	Summer	Winter	Summer	Winter
Number of scats	483	301	290	773
Pollock	7	12	46	53
Pacific cod	6	26	18	39
Atka mackerel	96	55	32	43
Salmon	17	6	38	25
Herring			35	1
Sand lance	4	1	34	28
Arrowtooth	1	1	8	21
Irish Lord sp.	3	23	11	33
Sand fish	1	5	16	11
Halibut		1	1	10
Cephalopods	13	18	7	4
Rock sole	0	6	19	14
Snailfish sp.	1	12	1	14
Capelin			2	0
Poacher sp.			14	1

One test for the “*junk food*” hypothesis is to forgo consideration of past ocean-climate regime change and contrast the recent situation in the western and central Aleutians (Areas 541 – 543) against the situation in the eastern Aleutian Islands (Area 610). Table 5.1 provides stark contrast in the observed diets of sea lions between the two areas. Atka mackerel dominant the diet in the western and central Aleutian Islands, but in the eastern Aleutian Islands, the diet is more diverse and contains more energy-rich species such as salmon, herring, and sand lance. Based on lipid and protein contents, Logerwell and Schaufler (2005) ranked the following prey species from highest to lowest nutrition: Pacific herring, sand lance, rockfish, Atka mackerel, surf smelt, capelin, salmon, sandfish, adult pollock, yellow Irish lord, juvenile pollock, Pacific cod, squid, skate, rock sole, smooth lump sucker, and snailfish (cited on [BiOp, 116]). Sea lions eat more nutritious prey (herring, sand lance, and salmon) along with less nutritious prey (pollock, Pacific cod, and Atka mackerel) in the eastern Aleutian Islands.

Necessary conditions for accepting the “*junk food*” hypothesis would be based on circumstances across the Aleutian Islands. Acceptance would be warranted if:

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- a) condition (relative size and weight) of adult sea lions is similar across the Aleutian Islands areas;
- b) condition of pups is as good as or better in the western and central Aleutians Islands;
- c) birth rate is lower in the western and central Aleutian Islands;
- d) pups/juveniles suckle to an older age in the western and central Aleutian Islands; and
- e) foraging trips by sea lions in the western and central Aleutian Islands are shorter and more time is spent resting on shore.

Statements in the BiOp and Figure 4.6 indicate that conditions (a) and (e) cannot be tested due to a lack of data:

“Given that no measurements have been made for adult Steller sea lions in the Alaska portion of the western DPS since the 1990s (other than numbers of individuals from population counts), changes in body condition, reproductive success, and foraging parameters that would be direct indicators of acute or chronic nutritional stress are currently unknown for adults, except for those estimated [predicted, our addition] by demographic models (York 2003, Fay 2004, Fay and Punt 2006, Holmes et al. 2007).” [BiOp, 118]

More information is available on pups (Figure 4.6), and is consistent with condition (b) above:

“Body condition of SSLs in the western DPS is relatively good (i.e., compared to body condition in animals from the eastern DPS), particularly for pups. Data recently collected on pups in the Aleutian Islands, Gulf of Alaska, Prince William Sound, and Southeast Alaska show that they are generally healthy and in good condition throughout their range in Alaska (Rea et al. 2010) indicating nutrition is sufficient to produce healthy young and sustain healthy juveniles and adults. Another indicator of SSL condition, skull size, hasn’t changed as it likely would have if nutritional stress were the primary issue over the last 2-3 decades (Trites et al. 2008).” [BiOp, xxx]

“Contrary to what would be expected for animals experiencing acute nutritional stress, Steller sea lion pups in the early 1990s were heavier in the areas of population decline (i.e., the western DPS) than in rookeries where the population was increasing (Merrick et al. 1995). Pups at two rookeries within the area of decline were heavier in 1992-93 than prior to the decline in 1965 and 1975. Similar results were reported by Davis et al. (1996; 2006) who found no significant differences in pup birth sizes between declining and stable populations in the 1990s; nor were there differences in adult female body mass or composition.” [BiOp, 114]

Other parts of the BiOp with evidence for and against the “junk food” hypothesis relative to survival rates and body condition of juvenile sea lions are confusing:

(R)esult(s) from captive feeding experiments suggests that in areas with a high proportion of gadid(s) in the diet (e.g., central Gulf of Alaska, eastern Aleutian Islands), juvenile survival and condition should also be low. However, survival of juvenile sea lions in the 2000s in the eastern Aleutian Islands and central Gulf of Alaska has

improved considerably since the 1980s (Figure 3.16), while juvenile condition based on animals captured and instrumented at-sea has been high (Fadely et al. 2005; Lander et al. 2009, NMML unpublished); both of these findings are contrary to the results predicted by the juvenile nutritional stress hypothesis (the “junk food” hypothesis) proposed Trites and Rosen (2003) and summarized by Rosen (2009).” [BiOp, 117]

This quote shows a lack of understanding in the BiOp about the “junk food” hypothesis, and a failure to recognize that the diet of sea lions in the eastern Aleutian Islands consists of much more than gadids (Table 5.1). Captive studies have not shown poor survival of juveniles. Instead, they have shown that young sea lions get full on a low-energy diet and are unable to acquire sufficient energy on their own to maintain normal growth and activity (Rosen and Trites 2004; Rosen 2009). Females that keep their pups for an extra one or two years should enhance the survival and condition of their juveniles. Thus, what is claimed in the BiOp as evidence for rejection is the very piece of evidence (robust juveniles) that meets a necessary condition for acceptance of the “junk-food” hypothesis.

These are not the only misinterpretations found in the BiOp concerning the “junk-food” hypothesis. Conclusions in Rosen (2009) were misinterpreted [BiOp, 285], the wrong test subjects (juveniles instead of adults) were reported for Calkins *et al.* (2005) [BiOp, 156], conclusions were attributed to Pitcher *et al.* (2000) [BiOp, 111] and to Rosen (2009) [BiOp, 285] that they did not make, and papers by Merrick *et al.* (1997) and Trites *et al.* (2007a) linking diversity in diets to rates of change in population abundance of sea lions were omitted entirely.

Information on trends in pup counts in the western, central, and eastern Aleutian Islands shows that the necessary condition (c) is met for the “junk-food” hypothesis (Table 5.2, Figure 5.1, Figure 5.2). Counts trend higher from west to east in recent years, and trend higher as the diet of sea lions changes from a reliance of moderately nutritious Atka mackerel in the western and central Aleutian Islands to a more diverse diet containing more nutritious species (herring and sand lance) in the eastern Aleutian Islands (Table 5.1). Although trends in pup counts are not the same as birth rates (see our Chapter 4), a decline in birth rates would cause a decline in the counts of pups. The difficulty in obtaining direct estimates of birth rates with counts only is explained in the BiOp:

“While rookery pup to non-pup ratios are not estimates of actual female natality (since they include juveniles and males in the denominator), they provide insight into the relative birth rates of females within each region since females dominate rookery populations. For example, pup to non-pup ratios can be reduced because there are few pups per female, and because dependent juveniles from births in previous years are present with their mothers on the rookery. Both of these factors, however, would suggest reduced birth rates compared with rookeries with higher ratios. The extent to which sub-adult males and other weaned juveniles haul out on rookeries will also affect pup to non-pup ratios and can vary between rookeries independent of differences in natality.”[BiOp, 85]

Table 5.2.—Counts of sea lions by area and percentage trends of pups and non-pups in the Aleutian Islands along with FOs (frequency of occurrence) for prey of sea lions as determined from scats (see Table 5.1). [Segment of BiOp, Table 5.8]

SSL Sub-Region	Fishery Management Area	RCA	Trend Sites (n)/Rookeries (n) ¹	Non-Pup Counts at SSL Trend Sites 2008A ²	SSL Trend Sites Avg Annual Growth Rate, 2000-2008 (%)		Overall Difference in SSL Counts, 2000-2008A (%)		Pups (2009): Adult Females (2008) ⁵	Primary Prey (% FO) ⁶	
					Non-Pups ³	Pups ¹	Non-Pups ²	Pups ⁴		Summer	Winter
Western AI	543	1	10/4	894	-7	-11	-45	-43	0.29	Atka mackerel (96), Salmon (17), Cephalopods (13), Pollock (7), P. Cod (6)	Atka mackerel (55), P. Cod (26), Irish Lord (23), Cephalopods (18), Pollock (12), Snailfish (12)
Central AI	542	2	12/4	772	-4	-4	-11	-7	0.39		
	542	3	12/4	1896	-1	-4					
	541	4	13/2	1351	-3	2					
	541	5	12/2	1645	2	2					
Eastern AI	610	6	31/7	6519	3	5	28	47	0.37	Pollock (46), Salmon (38), Herring (35), Sand Lance (34), Atka mackerel (32), Rock Sole (19), P. Cod (18)	Pollock (53), Atka mackerel (43), P. Cod (39), Irish Lord (35), Sandlance (28), Salmon (25), Arrowtooth (21)
	610	7	16/5	5274	5	3					

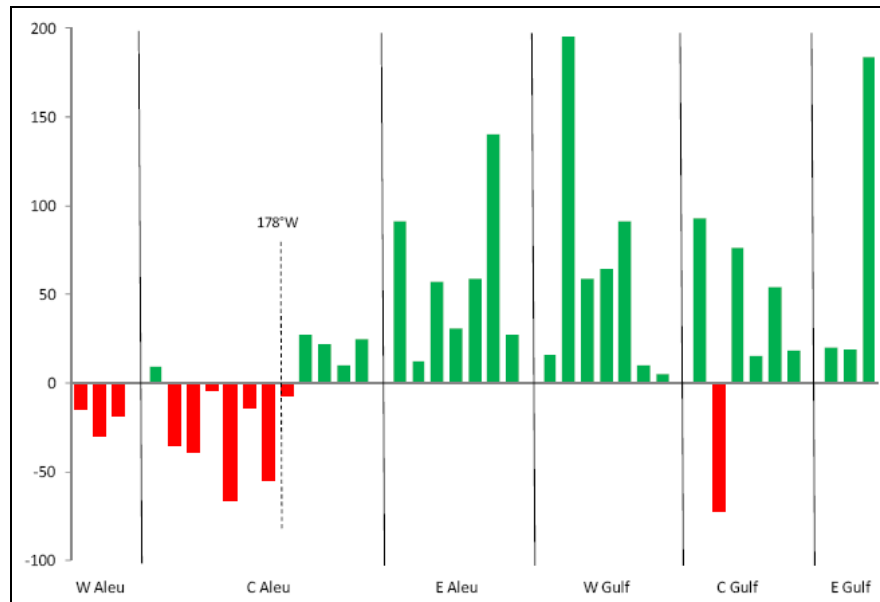


Figure 5.1.—Change in pup count by rookery between 2005 and 2009 across the range of the western DPS in Alaska. Red bars indicate decline in rookery production, while green bars indicate an increase. W, C, and E Aleu = western, central (areas 541-3), and eastern Aleutian Islands (Area 610); W, C, E Gulf = western, central, and eastern Gulf of Alaska. [Figure 3.10 from the BiOp]

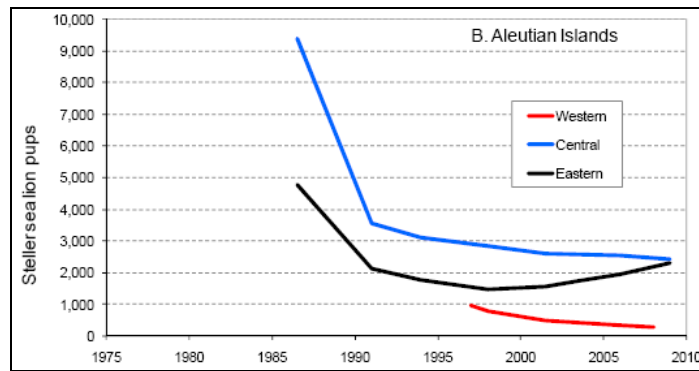


Figure 5.2.—Steller sea lion pup counts at trend rookeries in the range of the western stock in Alaska by region from the late 1970s to 2009 in the Aleutian Islands (B). [BiOp, Figure 3.9, Panel B]

Age at weaning has been estimated in Southeast Alaska (Marcotte 2006; Trites *et al.* 2006), but is not discussed in the BiOp. We are unaware of studies in which the age of weaning has been estimated for the eastern, central, and western Aleutian Islands. Until such estimates are available, condition (d) must remain untested.

We conclude that the conditions (b) and (c) (pup condition and “birth rate”) have been met for the “*junk-food*” hypothesis while conditions (a), (d), and (e) (adult condition, time to wean, and foraging frequency) remain untested for lack of pertinent information. Note that our conclusions do not confirm the “*junk-food*” hypothesis, only establish that this hypothesis is consistent with the available sea lion data, and can not be rejected as impeding recovery of sea lions in the western and central Aleutian Islands at this time.

Consideration of the “*junk food*” hypothesis in the BiOp did not end with a definitive conclusion as to its relevance. Instead, the BiOp concludes that it is highly unlikely that that large population declines could be caused by natural changes:

“Given an 80% reduction in the western DPS of Steller sea lions, a general lack of robust population growth, and the lack of evidence suggesting sustained high levels of anthropogenic removals, it is likely that the environmental carrying capacity has been reduced either through natural environmental changes or human induced changes. Given the equivocal data surrounding the dietary needs of Steller sea lions, the consequences of climate regime shifts, and massive population declines, it is highly unlikely that natural environmental change has been the sole underlying cause for the decline of Steller sea lions. Therefore, this consultation looks to this and other possible causes of the decline recognizing that environmental change is an important component in this equation, and may combine with other factors to contribute to the past decline in abundance of the western population of Steller sea lion and the current lack of recovery.” [BiOp, 162]

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This conclusion is contradicted by the anthropological record that shows significant declines of sea lions have occurred repeatedly in the past before the arrival of industrial fisheries (Maschner *et al.* 2010).

The “junk food” hypothesis is not named as such in the Executive Summary of the BiOp, but is mentioned briefly:

*“The importance of nutritional stress (here the junk food hypothesis) in explaining the dynamics of the western DPS of Steller sea lions has been debated for decades. The current conclusion is that pollock in adequate availability can sustain healthy populations of SSLs, although it is equivocal how long sea lions can consume only pollock and continue to gain weight. For optimal foraging, SSLs require a diversity of prey species. SSLs have adapted to seasonal sources of high energy prey and to the mix of prey species present in their foraging areas (Trites *et al.* 2007a; Rosen 2009; Sigler *et al.* 2009; Winter *et al.* 2009; Womble *et al.* 2009).”* [BiOp; xxx, 342]

Sea lions in the western and central Aleutians eat few pollock and do not have the “diversity of prey species” in their diets found east of Areas 541 – 543 (Figure 5.1). Nine paragraphs later in the Executive Summary, on the next page, the conclusion is given that fisheries jeopardize recovery.

Killer Whale Predation

The significance of predation on Steller sea lions by killer whales continues to be a complex issue that is identified as one of the important threats to recovery of the Steller sea lion WDPS by the National Research Council, NMFS, the Steller sea lion recovery team, and others.

The NRC (2003) report which examined causes for the decline of Steller sea lion in Alaska waters states,

“The possibility that killer whale predation is a major factor in the decline of the Steller sea lion population is not easily dismissed. Killer whales are abundant, intelligent, behaviorally flexible, and known to be rapacious consumers of large marine mammals. The predation of killer whales on Steller sea lions was previously thought to be minor, but recent reevaluations of their abundance suggest that killer whales could be a major source of sea lion mortality”.

The revised Steller Sea Lion Recovery Plan (NMFS 2008) ranks predation by transient killer whales potentially high and states,

“Thus, as noted previously, due to the uncertainty and the need to be precautionary in our assessment of possible threats to the recovery of this endangered DPS, NMFS has categorized the relative potential impact of this threat as “potentially high”. Due to competing theories about the likely importance of killer whale predation on Steller sea

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lions, but limited data, the potentially high ranking was assigned to ensure we further evaluate the potential for predation to affect sea lion recovery.”

NMFS, in their most recent Alaska marine mammal stock assessments (Allen and Angliss 2010), citing the revised Steller sea lion recovery plan (NMFS 2008) and a number of studies that examined the role of transient killer whales in the North Pacific ecosystem and impacts on Steller sea lions (Springer *et al.* 2003; Williams *et al.* 2004; DeMaster *et al.* 2006; Trites *et al.* 2007b), identified predation by killer whale predation as one of the potentially high threats to recovery of the wDPS.

In the BiOp’s Status of Species and critical habitat section, NMFS states:

“Mammal-eating killer whales and/or predation from other sources can have considerable impact on SSL populations, particularly when a sub-region is comprised of only small numbers of SSLs. Williams et al. (2004) examined the energy needs of killer whales and the potential caloric energy provided by various prey. Using bioenergetics and demographic modeling, Williams et al. (2004) reported that fewer than 40 killer whales could have caused the recent Steller sea lion decline in the Aleutian archipelago, and a pod of five could suppress a low population. Springer et al. (2003) similarly noted the impact of small numbers of killer whales on a depressed SSL population. Durban et al. (2010) surmised that currently a small number of killer whales has the potential to limit recovery of the depressed SSL population in the central AI region. Guenette et al. (2007) similarly noted the significant source of SSL mortality from killer whales during the 1990s when SSL numbers were low. These observations, modeling efforts, and energetics research collectively point to the imposing potential impact of killer whale or other sources of predation on SSLs when SSL abundance is low, often called the predator pit concept. These studies give some insights into predator impacts on SSLs, but are based on limited observation or are based on calculations or modeling.” [BiOp, 111]

In the BiOp’s Environmental Baseline section, NMFS states:

“Nonetheless, there is ample literature to suggest that in some areas, particularly areas of low Steller sea lion abundance (e.g., the central Aleutian Islands), killer whale predation can be an important factor in either causing continued declines or contributing to a lack of a robust recovery (see Heise et al. 2003; Williams et al. 2004; Williams 2006; Guénette et al. 2007; Durban et al. 2010).” [BiOp, 173]

Additionally in the BiOp’s Synthesis and Conclusion section, NMFS states,

“Killer whale predation may be locally high and could be suppressing Steller sea lion recovery in some parts of the Aleutian Islands (e.g., Durban et al. [2010] reported very high numbers of killer whales in the central and eastern Aleutians) and are thought by some to be the single greatest source of mortality for juvenile SSLs in the eastern GOA region (Horning and Mellish 2010a).” [BiOp, 342]

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Based on the discussion in the BiOp of the bioenergetics requirements for transient killer whales estimated by Williams *et al.* (2004), just a small proportion of the transient killer whale population estimated to minimally contain 552 individuals in the Gulf of Alaska and Aleutian Islands / Bering Sea eating sea lions would account for a sufficient amount of mortality to continue the declines in sea lion numbers at rookery and haulout sites in the areas of concern in BSAI.

Predation by transient killer whales related to recovery efforts for Steller sea lions needs further study to confirm or refute the influence of transient killer whales in the continued declines of the western BSAI Steller sea lion. However, the limited information collected on numbers and diets of killer whales in Alaska, the data obtained from mortality tags implanted in sea lions, and the results of energetics and ecosystem models indicate that a few killer whales can have a large effect on sea lion survival rates, particularly when sea lion numbers are low.

Summary

Of the two alternate hypotheses concerning the reduced numbers of Steller sea lions in the western and central Aleutian Islands, we conclude that neither the “junk food” hypothesis nor the “killer whale predation” hypothesis can be scientifically rejected with available data at this time. Both remain viable explanations of sea lion demographics. Of the five necessary conditions for acceptance of the “junk food” hypothesis, there is evidence supporting one (good pup condition) and perhaps another if low pup to non-pup ratios in the western and central Aleutian Islands have been related to low birth rates. Unfortunately there is no information on the other three necessary conditions (normal adult body condition, short foraging trips, and older age at weaning for pups).

While the BiOp contained no conclusion as to rejecting or not rejecting the “junk food” hypothesis, the BiOp did state “killer whale predation can be an important factor in either causing continued declines or contributing to a robust recovery (of sea lions).” While this statement is not an endorsement of the killer whale predation hypothesis (“is” would have been the verb of choice, not “can”), we interpret this statement to be an admission by NMFS that the “killer whale predation” hypothesis cannot be rejected at this time. We concur.

The BiOp did not address the contingency that both the “killer whale predation” hypothesis and the “junk food” hypothesis are not mutually exclusive. Both can be in effect at the same time, and perhaps are in the central and western Aleutian Islands.

It is not clear why the BiOp excluded viable alternative hypotheses (which cannot be rejected at this time) from consideration in their Chapter 8 [Reasonable and Prudent Alternative(s)]. We found no evidence that killer whales or diets and satiation of sea lions were part of the multi-species modeling cited in the BiOp; and killer whales and diets could not be part of single-species models used to gauge effectiveness of RPAs. Instead, Chapter 8 of the BiOp dealt with only one hypothesis—fishery-driven nutritional stress—a hypothesis that is not supported by statistical associations or by scientific evidence.

6. THE BI-OP'S ANALYSIS OF EFFECTS OF RPA'S

In their Summary and Conclusions, Chapter 7 in the BiOp, NMFS writes:

“After reviewing the current status of critical habitat that has been designated for the western population of Steller sea lions, the environmental baseline for the action area, the proposed action for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS’ Biological Opinion that the action, as proposed, is likely to adversely modify the designated critical habitat for the western DPS of Steller sea lion.”[BiOp, 348]

This conclusion resulted in the development of reasonable and prudent alternative (RPAs) to the action, that is, modifications to the FMP for groundfish fisheries in the BSAI management area.

The RPAs for Area 543 are to prohibit the retention of Pacific cod and Atka mackerel in directed fisheries in the entire area and to establish a total allowable catch (TAC) for Atka mackerel in fisheries in which they are incidentally caught [BiOp, 361]). The expressed biological expectations for this RPA are an increase in biomass in the area by 2020 of 42% for Atka mackerel and 119% for Pacific cod resulting in a 17% increase in overall groundfish biomass in the area (Table 6.1).

The RPAs for Area 542 involve groundfish in general and specifically Pacific cod and Atka mackerel. Fisheries directed at Pacific cod are prohibited during November and December throughout the area, and are prohibited for trawl or long-line fisheries during the rest of the year in part or in all of the critical habitat in the area. For Atka mackerel fisheries, RPAs involve a reduction in the total allowable catch in the entire area, complete or partial prohibitions of fishing in the critical habitat, a limit for catches in those parts of critical habitat in which fishing is still allowed, and an allocation among users. The RPA for groundfish fisheries in general involves a prohibition of part of a specific critical habitat [BiOp, 364-5]. The expressed biological expectations for these RPAs is an increase in biomass by 2020 of 7% for Atka mackerel and 22% for Pacific cod resulting in a 4% increase in overall groundfish biomass (Table 6.2).

Table 6.1.—“Summary of results from projection model regarding closure of Area 543 to fishing for Pacific cod and Atka mackerel (from Ianelli et al. 2010b).” [BiOp, 363, in-text table]

<i>Groundfish Species</i>	<i>Year 1 (biomass – kt)</i>	<i>Year 11 (biomass – kt)</i>	<i>(% change)</i>
<i>Atka mackerel</i>	<i>244.1</i>	<i>374.3</i>	<i>+42%</i>
<i>Pacific cod</i>	<i>17.7</i>	<i>38.8</i>	<i>+119%</i>
<i>All Groundfish Species</i>	<i>721.7</i>	<i>846.0</i>	<i>+17%</i>

Table 6.2.—“Summary of results from projection model regarding closure of Area 542 to fishing for Pacific cod and Atka mackerel (from Ianelli et al. 2010b).” [BiOp, 369, in-text table]

<i>Groundfish Species</i>	<i>Year 1 (biomass – kt)</i>	<i>Year 11 (biomass – kt)</i>	<i>(% change)</i>
<i>Atka mackerel</i>	<i>290.0</i>	<i>311.4</i>	<i>+7%</i>
<i>Pacific cod</i>	<i>22.4</i>	<i>27.4</i>	<i>+22%</i>
<i>All Groundfish Species</i>	<i>702.3</i>	<i>728.7</i>	<i>+4%</i>

The RPAs for Area 541 involve only fisheries for Pacific cod. Directed fishing for this species is prohibited in all near-shore portions of critical habitat at all times for fisheries, prohibited in all offshore portions of critical habitat for parts of the year according to the type of gear used, and prohibited during November and December everywhere across Area 541 [BiOp, 370-1). No biological expectations were presented in the BiOp other than a reduction in the spatial overlap between fishing and foraging sea lions.

Expectations for the WDPS of Steller Sea Lions from RPAs

Collectively, the RPAs for Areas 542 and 543 are expected to result in an annual rate of increase of 2.5% per year in abundance of Steller sea lions for the entire WDPS, that is, a 31% increase (our calculation) in the size of the WDPS by the end of 2018:

“If measures for the western and central Aleutian Islands implemented in the RPA described above are approximately as effective in reducing fishing effects on Steller sea lion populations in the western and central Aleutian Islands as the measures implemented as a result of the prior two Biological Opinions appear to be at reducing fishing effects on Steller sea lion populations in the eastern Aleutian Islands, and western and eastern GOA, the western DPS would be expected to be increasing at a robust rate (i.e., approaching 3% per year) with no additional conservation measures”. [BiOp, 375]

“... if the number of sea lions in the western Aleutian Islands sub-region increased by 6.0 percentage points per year by closing the western Aleutian Islands sub-region to commercial fishing and if the number of sea lions in the central Aleutian Islands sub-region increased by 1.5 percentage points per year by adding additional restrictions to commercial groundfish fisheries in the central Aleutian Islands, and if all other trends by subregions remained constant through 2018, the resulting rate of increase for the entire western DPS of Steller sea lion would be approximately 2.5% per year, no two juxtaposed areas would be in significant decline, and no single area would have a realized a decline of 50% or more.” [BiOp, 375]

The expectations for sea lions comes from assuming that what happened following earlier RPAs from prior BiOps concerning the WDPS in the eastern Aleutian Islands and the GOA will be repeated with the current RPAs for the western and central Aleutians.

Predicting Responses to RPAs

Two ways of predicting the effects of RPAs on sea lion recovery were investigated in the BiOp:

- a multi-species, scientific approach, and
- a single-species, empirical approach (our labels).

In the multi-species approach, food webs of known predator-prey relationships, including sea lions, were modeled. Randomly selected sets of parameter values represented different versions of reality so that simulated results followed a probability distribution. Simulated fisheries were restricted, and responses of the species, including sea lions, were directly predicted. Advantages of this approach are that it encapsulated what is known of the structure of the food web, and directly predicts the response of sea lions to fishery restrictions. The disadvantage is that the relative strengths of connections in the food web are not well known despite knowing the form of the food web.

Results from multi-species modeling described in the BiOp generally show that restricting fisheries does *not appreciably increase sea lion biomass*. We discussed two such modeling efforts in Chapter 4, one for the Gulf of Alaska (Dorn *et al.* 2005; NMFS 2006b), and the other for the western and central Aleutian Islands (Aydin 2010). Summarizing the results from the study on the Gulf of Alaska:

“For Steller sea lions, the model predicts that the cessation of fishing would cause Steller sea lions to increase in biomass (50% confidence intervals [sic] is between 2-10% increase). It is important to note that this effect, similar to that for pollock, is also dampened over time.” [BiOp, 253]

As stated in Chapter 4, reliance on a 50% confidence interval to indicate an “*increase*” in the biomass of sea lions is lamentable, especially since that simulated increase is temporary. The convention in statistical analysis is a 1-in-20 chance of error in judgment ($\alpha = 0.05$), not the 1-in-2 chance implied with the 50% confidence interval ($\alpha = 0.50$). *In short, no long-term effects were predicted in sea lion biomass in the GOA from restrictions on fishing in the two previous BiOps.* These results indicate that any increases in sea lion biomass in the GOA due to restricting fisheries will be short-lived at best.

Results from modeling the western and central Aleutian food web are marginally better, at least from closing fisheries on Atka mackerel (Aydin 2010). An expected increase of 6% (our interpolations from Figure 4.6) in sea lion biomass was predicted with restrictions on the Atka mackerel fishery in the area, but how many years were needed to realize that increase in the simulations was not specified. *No effect on sea lion biomass was predicted for restricting the fisheries for Pacific cod* (Figure 4.5).

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The second approach was to use single-species empirical models to predict the consequences of RPAs in the current BiOp instead of multi-species models. The “single-species” part of this approach is characterized in the BiOp as:

“It is recognized that the projections reported in Ianelli et al. (2010b) are based on single species models, which do not take into account multispecies interactions (e.g., predation).” [BiOp, 362]

“... the single-species stock assessment model draws projected recruitment from density-independent past recruitment rather than assuming a stock-recruitment relationship.” [BiOp, 255]

The “empirical part” of the approach is the inference that similar RPAs in two previous BiOps were associated with increases in sea lion biomass in the eastern Aleutian Islands and the GOA in the last decade. This approach is not based on science, but is based on experience. The inference was explained in a series of bulleted points in [BiOp, 375], the core of which are:

“Overall population trends for non-pups were stable (i.e., trend in abundance was - 0.1%) from 2000-2008 in this sub-region.” (the GOA and the eastern Aleutian Islands) [BiOp, 375]

“Overall population trends for pups were increasing (i.e., increase in number of pups born between 2001/2002 and 20009 [sic] was 6%) in this sub-region.” [BiOp, 375]

“... For example, if the number of sea lions in the western Aleutian Islands sub-region increased by 6.0 percentage points per year by closing the western Aleutian Islands sub-region to commercial fishing and if the number of sea lions in the central Aleutian Islands sub-region increased by 1.5 percentage points per year by adding additional restrictions to commercial groundfish fisheries in the central Aleutian Islands, and if all other trends by subregions remained constant through 2018, the resulting rate of increase for the entire western DPS of Steller sea lion would be approximately 2.5% per year, no two juxtaposed areas would be in significant decline, and no single area would have a realized a decline of 50% or more.” [BiOp, 375]

These quotes can be distilled down to the phrase “what worked there and then, will work here and now” with “what” being fishery restrictions, “there” being the GOA and eastern Aleutian Islands, “then” representing the previous decade, and “here” being the western and central Aleutian Islands. This empirical link is needed because there is no model for sea lions in the suite of independent single-species models. Such a link is an integral part of the multi-species models.

The rationale given as to why the single-species, empirical approach was chosen over the approach based on multi-species models is the uncertainty associated with the latter models:

“Thus, NMFS examined the results of both single-species and multispecies models of reduced Atka mackerel and Pacific cod fishing mortality in the Aleutian Islands overall and in Area 543. As noted in Van Kirk et al. (2010), the decision of which approach to

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use depends on the objectives. Trade-offs must be made between the advantage of greater biological realism via multispecies information and the disadvantage of increased uncertainty due to additional model complexity (Van Kirk et al. 2010). Here we note that uncertainties inherent with the assumptions of single-species approaches become magnified in multispecies models. Therefore, NMFS believes that given the information available, it is premature to add more assumptions to the models predicting predator-prey responses and has relied on the results of the single species models to a greater extent than the multispecies models in predicting the effects of the RPA.” [BiOp, 362]

This rationale is flawed. By rejecting food-web models in favor of single-species models, NMFS has not reduced uncertainty so much as hidden it. With this choice of approach, NMFS has disregarded the facts that Pacific cod eat Atka mackerel, that fisheries take both species, and that there is a background of prey for sea lions that is not fished. It is true that food-web models will have more parameters than single-species models and are more complex. However, using single-species models in this instance ignores the strongest scientific information available—the knowledge that the dynamics of these species are linked. Using single-species models as was done in evaluating the effectiveness of RPAs ignores best science in favor of methods that have a guaranteed outcome. The advice in Van Kirk *et al.* (2010) is to pick the simplest model *that meets objectives*, not just pick the simplest model.

By using independent, single-species models without a stock-recruit relationship, NMFS *guaranteed that virtual fish biomass would rise with virtual restrictions*. The exact methods used in the single-species modeling were not described in Ianelli *et al.* (2010a), so we do not know the exact methods they used. However, the modeling is simple in concept. We therefore constructed a single-species model for our review. We selected the simple single-species model $B_{t+1} = (R_t + B_t)S_M S_F$ where B is biomass, S_M the survival rate from “natural” causes and S_F a survival rate from fishing. Simulations were independently conducted by randomly and independently drawing recruitment (R_t) from a normal probability distribution with mean and SD arbitrarily chosen (19, 5). Serial correlation among recruitments and density-dependent effects were not modeled. Other parameters were $B_0 \leftarrow 80$, $S_M \leftarrow 0.9$, and $S_F \leftarrow 0.9$ for ten years, then $S_F \leftarrow 1$ thereafter. We found (Figure 6.1) that the arbitrary choice of parameters we used appeared to have been fortuitous, in that a beginning and stable biomass increased 120% in the demonstration, almost exactly the projected 119% increase of Pacific cod in Area 543 from Ianelli *et al.* (2010b) as reported in the BiOp (see Table 6.1).

The irony here is that *use of single-species models in the second approach is moot*. The inference at the heart of the “empirical” part of this single-species, empirical approach associates fisheries with sea lions *without the need to reference prey biomass at all*.

NMFS is faced with a dilemma in that their own multi-species modeling shows that previous restrictions on fisheries from two previous BiOps were inconsequential to sea lion recovery in the eastern Aleutian Islands and the Gulf of Alaska. Nominal increases in sea lion biomass were not statistically significant in simulations, and then waned with time:

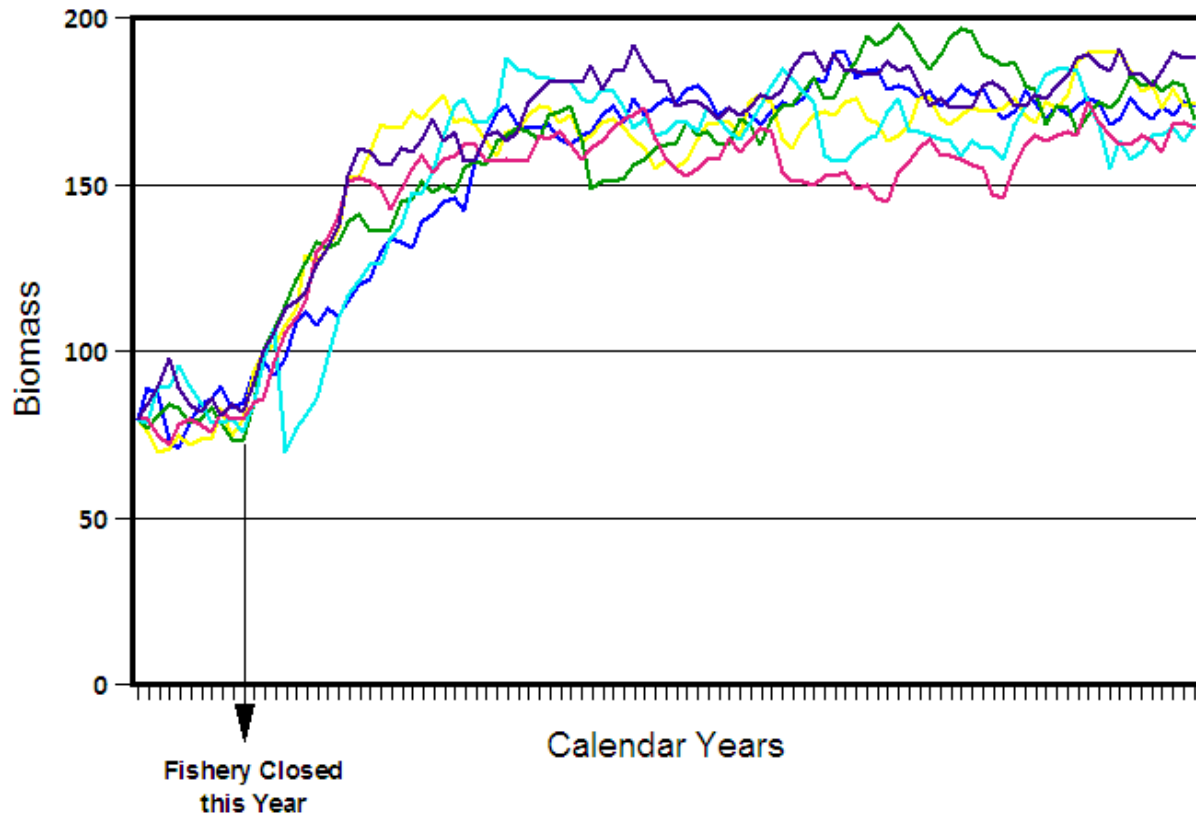


Figure 6.1.—Demonstration of a single-species biomass model before and after virtual fishing ceased. Six trajectories are displayed. Model is described in text.

“For Steller sea lions, the model predicts that the cessation of (all) fishing would cause Steller sea lions to increase in biomass (50% confidence intervals [sic] is between 2-10% increase). It is important to note that this effect, similar to that for pollock, is also dampened over time.” [BiOp, 253]

Results from NMFS multi-species models for the Gulf of Alaska and the eastern Aleutian Islands are consistent with the only statistical investigation (Calkins 2009) that covers the period after application of the first set of RPAs (2001). Calkins (2009) found 13 statistically non-significant associations, 7 significant positive ones, and 0 significant negative ones between fishing for Pacific cod and sea lion numbers (Chapter 3, Tables 3.1, 3.2). Another interpretation of the results in Calkins (2009) is that restrictions in the RPAs for the earlier BiOps were sufficient to make fishing an inconsequential source of mortality for Pacific cod, essentially turning the fishery into a means of indexing abundance of Pacific cod (and an explanation for significant, positive associations). However, a perusal of estimated harvest rates for the eastern Aleutian Islands/Gulf of Alaska indicate that harvest rates changed little before and after restrictions in

Table 6.3.—Estimated catch rates, estimated biomass, and catch of Pacific cod in the western and central Gulf of Alaska (GOA) from 1999 through 2009. Averages are for the shaded years and are to be compared back to statistics for 1999. [From parts of BiOp, Tables 5.5, 5.6]

Year	Est. Catch Rates		Estimated Biomass		Catch	
	Western GOA	Central GOA	Western GOA	Central GOA	Western GOA	Central GOA
1999	17%	17%	140,108	259,755	23,150	45,132
2000	15%	14%	142,290	235,612	21,867	32,440
2001	10%	13%	144,473	211,469	14,161	27,366
2002	14%	13%	125,723	189,751	17,177	25,201
2003	20%	18%	106,974	168,033	21,801	30,675
2004	20%	21%	110,631	165,950	21,798	34,625
2005	16%	18%	114,288	163,866	18,078	29,428
2006	18%	17%	111,120	161,534	20,091	27,612
2007	18%	20%	107,952	159,202	19,220	32,006
2008	16%	17%	128,512	214,601	20,973	37,532
2009	12%	11%	149,072	270,000	17,248	30,151
Average	16%	16%	124,104	194,002	19,241	30,704

2001 (Table 6.3). If fishing was an inconsequential source of mortality of Pacific cod after 2001, then it must have also been an inconsequential source before.

Summary

NMFS chose to demonstrate the effectiveness of RPAs in the BiOp using single-species modeling, rather than the multispecies modeling of Aydin (2010). This choice required NMFS to embrace the assumption that restricting fisheries worked in the Gulf of Alaska, and should therefore work to the same degree in the western and central Aleutian Islands. Unfortunately, this assumption is contrary to results from multi-species modeling for the western and central Aleutian Islands, and contrary to multi-species modeling for earlier restrictions in the Gulf of Alaska. Ironically, using this empirical argument makes the results of single-species modeling reported in the BiOp irrelevant to justifying the effectiveness of RPAs. The correct approach to gauging the effectiveness of RPAs in this BiOp would have been to include ecosystem considerations that rely on multi-species, food-web models that directly include sea lions.

Evidence presented in the BiOp from multispecies modeling indicates unequivocally that any future increase or stabilization in sea lion biomass in the western and central Aleutian Islands will *not* be due to restricting fisheries for Pacific cod. Multispecies modeling by Aydin (2010) predicted no effect on sea lion biomass from lowering harvest rates in Pacific cod fisheries. Multispecies modeling to test the efficacy of past RPAs on Pacific cod for the Gulf of Alaska and Eastern Aleutian Islands from past BiOps indicate those RPAs to have been ineffective as well. These latter results undercut the proposition central to the empirical argument in the BiOp that restricting fisheries worked in the Gulf of Alaska. These results are in line with statistical studies involving Pacific cod (see Chapter 3) and scientific evidence discussed in Chapter 4.

In contrast, some modeling evidence presented in this BiOp indicates that halting fishing for Atka mackerel in the western and central Aleutian Islands might cause sea lion biomass to increase. Aydin (2010) predicted a 6% increase (our interpolations from the Figure 4.6) in sea lion biomass with a 10% percentage point reduction in the mortality rate the Atka mackerel. Because the harvest rate in the Atka mackerel fishery is 8%, the virtual 10 percentage point reduction represents closure of the fishery plus an additional two percentage point reduction in the mortality rate for this species. Unfortunately certain critical bits of information relative to evaluating this finding were not in the BiOp. Most notably, the BiOp does not explain or discuss:

- how mortality would be reduced the two extra percentage points beyond the closure of the virtual fishery;
- how many years were needed to realize virtual increases in sea lion biomass;
- whether these virtual increases persist; and
- what would the virtual effect of closing cod and mackerel fisheries be on sea lion biomass?

Without such information, the relevance of these simulations cannot be evaluated. However, this evaluation is probably of marginal value, considering that a meta-analysis of statistical studies described in our Chapter 3 showed no negative effects of fishing for Atka mackerel in the western and central Aleutian Islands on sea lion demographics in at least the last 20 years—or considering scientific evidence is inconsistent with fishery-driven nutritional stress affecting sea lions (our Chapter 4).

7. ECONOMIC ANALYSIS IN THE REGULATORY IMPACT REVIEW

Economic analysis related to the BiOp is found in the Regulatory Impact Review (Chapter 10 of *Revisions to the Steller Sea Lion Protection Measures for the Bering Sea and Aleutian Islands Management Area Groundfish Fisheries: Environmental Assessment/Regulatory Impact Review*, November 2010, which we refer to as the EA/RIR).

We considered the overall conclusions of the economic impact analysis as well as details of the analysis. We also addressed the question of whether the Reasonable and Prudent Alternatives (RPAs) are, as asked by our terms of reference,

...likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for SSL recovery?

We focused solely on a scientific review of the economic analysis, and neither offer nor intend any opinions on the legal questions of what economic analysis NMFS was required to conduct in its design or choice of RPAs or in writing the RIR, or whether it met these requirements.

Conclusions of the Regulatory Impact Review

The most important conclusions of the economic analysis are stated clearly and unequivocally in the Executive Summary of the EA/RIR:

“This action will impose relatively heavy costs on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands. The reduction in industry gross revenues—even after taking account of actions by firms to minimize their losses, shifting target fisheries, and potential increases in prices of species whose production has declined—are likely to be measured in millions of dollars. The analysis identified, for the preferred action, potential job losses of from about 250 to about 750 positions, depending on the success of the industry in finding new target fisheries. The preferred alternative is likely to have a substantial impact on the community of Adak, and to adversely affect Unalaska, and, to a greater or lesser extent, other communities in coastal Alaska. Some communities in Western Alaska participating in the CDQ program are also likely to be adversely impacted, depending upon their CDQ group’s allocation of Atka mackerel and Pacific cod TACs” [EA/RIR, xv]

We agree with this conclusion, and believe that it is supported by the analysis in the RIR (except that the projected reduction in industry gross revenues is better characterized as “measured in the tens of millions of dollars annually” [EA/RIR, 10-134]). Below we offer several comments about the analysis. However, addressing these comments would not have changed, but rather strengthened, the conclusion that the action “*will impose relatively heavy costs on the fishing and processing industry*”.

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A second important conclusion of the economic analysis, also stated in the Executive Summary, is the following:

“As discussed in the analysis, the preferred alternative disrupts fishing and reduces fishery gross revenues the least, reduces the number of jobs the least, and, consequently, imposes the least adverse impact on affected communities, all else equal.” [EA/RIR, xv]

This statement is technically true but is also misleading. As we discuss in the final part of this chapter, it is true that the “preferred alternative” has the least impacts *of the alternatives analyzed in the RIR*. But this does *not* imply that the preferred alternative has the least adverse impact of all of the potential alternatives that might have had the same level of benefit for Steller sea lion recovery. Such an implication would be justified only if the process for development of the alternatives had described a necessary level of benefit for Steller sea lion recovery and had sought to identify an alternative which minimized economic impacts while achieving the necessary level of benefit.

General Comments on the Economic Analysis

This RIR characterizes the approach followed for the economic analysis as follows:

- *“First, the impacts of the alternative actions on the directly regulated vessels are evaluated. These alternatives restrict harvesting activity and lead to reductions in Atka mackerel and Pacific cod catches in the Aleutian Islands. The impacts are identified and described, and estimates of catch reductions are made, to the extent practicable.*
- *Second, the potential responses of the directly regulated vessels are evaluated. When vessel operators lose fishing opportunities for species in a given area, they will respond in one of several ways in an effort to minimize their losses. The most likely alternative opportunities are identified and described. Possible alternative species catch weights are estimated.*
- *Third, the impacts of the redeployment of the directly regulated vessels on the vessels already operating in the fisheries to which they redeploy, or in related fisheries, are evaluated.” [EA/RIR 10-46]*

This characterization of the analysis is correct. The approach was logical and reasonable given the available scientific and economic data, confidentiality limitations, and the ability of economics to model fleet responses to changes in fishing opportunities.

In general, the RIR’s analysis of economic impacts is reasonably complete, scientifically valid and adequate. It addresses the questions it should address objectively and reasonably, given the limits of available data and confidentiality restrictions.

It is impossible to predict precisely how the vessels and companies directly affected by the RPAs would respond over time to changes in their fishing opportunities, or the resulting indirect effects upon other fishing vessels and companies, support businesses, and communities. The RIR made a good-faith effort to identify and describe these responses and effects, while acknowledging the inherent limitations of the analysis.

Specific Comments on the Economic Analysis

As noted above, the most important conclusion of the economic analysis is that “this action will impose relatively heavy costs on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands” It would have been helpful to emphasize in the conclusions the additional important point that these heavy costs would fall disproportionately on certain companies and communities.

The RIR appropriately discusses the limitations of “revenues at risk” as a measure of economic impacts [EA/RIR, 10-107 through 10-109]. It would have been useful to include in this discussion the point that changes in fishing opportunities might have “tipping point” effects for some companies disproportionate to changes in fishing opportunities. As a simple example, if reducing a vessel’s catch by 10% causes the vessel’s operation to become unprofitable and the vessel to stop fishing, it could cause a 100% rather than 10% loss in employment on the vessel.

A similar “tipping point” argument applies to the potential effects of the RPAs on the community of Adak. Adak is a community struggling to become economically viable. Additional restrictions on Aleutian Islands fisheries could make the difference in whether it succeeds. This point was not clear in the analysis of potential impacts upon Adak (EA/RIR: 10-135, 10-136). The Executive Summary notes that Adak’s economic vulnerability stems in part from “fundamental structural difficulties with the community’s economic base” [EA/RIR, xiv]. Although we assume that the intended interpretation of this statement was that the potential impacts on Adak shouldn’t be attributed entirely to the RPAs, an alternative interpretation could be that the potential impacts of the RPAs could be multiplied by the fundamental structural difficulties with the community’s economic base.

The RIR includes an extensive discussion (Section 10.4, pages 10-86 through 10-105) of a study of potential non-market economic benefits of Steller sea lion recovery (Lew *et al.* 2010). It reports estimates that the non-market value of recovery of the western distinct population of Steller sea lions would have a present discounted value of many tens of billions of dollars (with the total amount varying depending on assumptions about the population growth rate and the discount rate).

The RIR notes that “*this survey-based evidence suggests that an improvement in the stock population growth has a large value.*” However, it also correctly notes that “*the element of uncertainty about the impact of the proposed action on Steller sea lion population trajectories makes it impossible to apply the survey results to this action to estimate its benefits to persons with non-consumptive motives for valuing the health of the population*”. [EA/RIR, 10-88]

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Put differently and more simply, the study by Lew *et al.* (2010) analyzed the total non-market value of known and certain recovery of the western distinct population. Their study said nothing about the marginal non-market value of the uncertain and un-estimated contribution to Steller sea lion recovery of the proposed alternative. As a result, Lew *et al.* (2010) is irrelevant to an analysis of the economic impacts and benefits of the alternatives.

The analysis by Lew *et al.* (2010) is no more relevant than, for example, an analysis showing that eliminating all the fisheries regulated by the NPFMC would cost the nation billions of dollars in revenue and destroy billions of dollars in investment. While true, such an analysis would be irrelevant since the proposed alternatives would not eliminate all fisheries regulated by the NPFMC—or even come close to doing so.

The inclusion of this non-market analysis in the RIR is potentially misleading because of the potential implication—despite clearly stated caveats—that the high non-market benefits reported by the study are in some way relevant.

It is revealing how this section of the RIR characterizes the scientific understanding of the benefits of the proposed actions for Steller sea lions:

“The RPA . . . notes that the ‘...effects of the RPA on the response of the Steller sea lion population cannot be projected with any amount of certainty with the available information ...’ (NMFS 2010:xxxvi.) The element of uncertainty about the impact of the proposed action on Steller sea lion population trajectories, makes it impossible to apply the survey results to this action to estimate its benefits to persons with non-consumptive motives for valuing the health of the population.”[EA/RIR 10-88]

The NMFS economists, in attempting to analyze economic benefits of the action, acknowledge that “*the element of uncertainty about the impact of the proposed action*” makes it impossible to say anything about what the benefits might be. It is therefore not surprising that members of the affected industry and communities, who face “*relatively heavy costs*,” should question the benefits of and justification for the action.

The methodology used by Lew *et al.* (2010) to estimate willingness-to-pay with household surveys is widely used by economists, and the analysis is reported in a peer-reviewed article. However, there is controversy associated with the reliability of this methodology to estimate non-market benefits of environmental benefits that are difficult to describe and of which most people have little direct understanding. There is also controversy associated with the potential biases of surveys in which respondents are asked about their willingness to pay without actually being required to pay, as well as other potential biases associated with all types of survey research. Our point here is not to debate these issues, but rather to point out that estimates of potential non-market benefits, such as the figures ranging from \$73 billion to \$119 billion (reported in [EA/RIR, 10-87]) have little meaning unless accompanied by a discussion of the level of uncertainty associated with them and the potential magnitudes of different types of biases.

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The RIR notes “*the accuracy of the WTP estimates is likely to be viewed with a critical eye.*” It argues that various studies have demonstrated that “*SP surveys can generate reliable estimates of WTP,*” that the analysis used “*state-of-the-practice*” methods, and that “*steps were taken to minimize the potential for biases,*” but concedes that “*it is possible the estimates may reflect some level of introduced bias*” [EA/RIR, 10-105]. However, it does not offer any discussion of what this level of bias might be, or how reliable estimates may reasonably be considered to be.

The RIR states, appropriately, “*because of the difficulty of identifying an appropriate time frame for this action, this analysis does not include an estimate of the present value of the revenue at risk for this action*” [EA/RIR, 10-125]. Particularly for non-economist readers, it is confusing and potentially misleading to present annual estimates of foregone revenues by industry while presenting estimates of the total present value over many years of the benefits of Steller sea lion recovery.

Statement that the RIR Provides a Cost-Benefit Analysis

The beginning of the RIR states that it provides a “cost-benefit analysis”:

“This regulatory impact review (RIR) provides a cost-benefit analysis of proposed changes to groundfish management required by the RPA. The analysis in this document addresses the statutory requirements of Presidential Executive Order (E.O.) 12866.” [EA/RIR, 10-1]

It is misleading to characterize the analysis in the RIR as a cost-benefit analysis, as it does not estimate the economic benefits attributable to the proposed changes to management.

Conclusion that the Preferred Alternative has the “Least Adverse Effect”

The Executive Summary of the EA/RIR includes the statement:

“As discussed in the analysis, the preferred alternative disrupts fishing and reduces fishery gross revenues the least, reduces the number of jobs the least, and, consequently, imposes the least adverse impact on affected communities, all else equal.” [EA/RIR, xv]

This statement is technically true but is also misleading. It is correct that the preferred alternative has the least impacts of the three alternatives analyzed by the RIR (Alternative 2: Enhanced Conservation Approach; Alternative 3: July 2010 Draft RPA Specific Approach; and Alternative 4: Preferred Alternative – Final RPA). But this conclusion does *not* necessarily imply that the preferred alternative has the least adverse impact of all of the potential alternatives that might have had the same level of benefit for Steller sea lion recovery.

Whether an alternative should be characterized as “least adverse” depends on how the alternatives were developed, and in particular how economics was used to develop the alternatives. Suppose two alternatives (A and B) are compared for any type of action, such as

their economic impacts. One (A) will have higher impacts and the other (B) will have lower impacts. Alternative B therefore has the least impact *of these two alternatives*. But it would be misleading to imply that B therefore has the least impact of all potential alternatives for this action.

**Why the Claim that the Preferred Alternative
Imposes the “Least Adverse Affect” is Misleading: An Analogy**

Suppose you are planning a move to a new city. You contact a realtor and ask him to assist you in finding a home for your family of four. As a “draft” proposal, the realtor suggests three homes for your consideration, priced at \$2 million, \$1.5 million, and \$1 million. The realtor recommends that you purchase the \$1 million home.

You express consternation at the cost of this alternative. You look in the real estate ads and note that there are a variety of homes selling in the \$200-\$400 thousand price range. You suggest that the realtor consider one of these homes as an alternative.

In response, the realtor produces his “final” proposal that ignores your suggestion but adds a fourth home priced at \$900 thousand for your consideration. He argues that this home is the “preferred alternative,” and he notes that it is the “least expensive alternative,” as there are no other alternatives which meet your needs.

But clearly this argument is not valid unless the realtor can explain what he is assuming about your needs, and show he has made a reasonable attempt to look for homes which would satisfy these needs. Yet if the realtor will not define what he assumes your needs to be, it will be impossible for you to argue that the home he says you should buy is unnecessarily large or overpriced.

This is the essential flaw in the claim of the RIR that “*the preferred alternative disrupts fishing and reduces fishery gross revenues the least, reduces the number of jobs the least, and, consequently, imposes the least adverse impact on affected communities, all else equal.*” The BiOp and the RIR never defined what standard an alternative was required to meet to provide an acceptable level of benefit for Steller sea lion recovery. Under the rationale of the fisheries-driven nutritional stress hypothesis, this criterion should have been defined in terms of necessary prey-field conditions, with analysis to support how the alternative would bring about these prey-field conditions.

Since NMFS did not provide such a standard in the draft BiOp, in drafting the Council’s August 2010 alternative, the fishing industry and the NPFMC were forced to guess at what kinds of lower-impact restrictions NMFS might consider acceptable. Just as the realtor rejected the suggestion of lower-priced homes, NMFS rejected the Council’s alternative in proposing a final preferred alternative with economic impacts almost as great as that of the draft BiOp. Without having defined the criterion for an acceptable alternative, or showing that it sought to identify lower-impact alternatives—and considered economic impacts in doing so—the claim by NMFS that the preferred alternative imposes the “least adverse impact” is misleading.

The claim is also misleading because there is no evidence that NMFS considered any economic analysis in developing RPAs. This is as if the realtor had selected the homes in his proposals without consideration of the prices—and then argued that the \$1 million house was the “least expensive option” because it was cheaper than the \$2 million or \$1.5 million houses.

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A claim that an alternative has the least economic impact of the alternatives that would achieve a certain level of benefit is reasonable only if both of the following conditions are met:

- The level of benefit provided by the alternative can be characterized, so that it is possible to know the benefit standard that other potential alternatives must meet.
- An attempt was made to identify an alternative meeting the benefit standard with the least economic impact.

Neither of these conditions was met in the development of the BiOp.

The benefit of an alternative is its effect on Steller sea lion populations. Ideally, the benefit standard would be characterized in terms of projected changes in rates of recovery of population segments. The BiOp does not do this. It specifically states that it cannot do this:

“ . . . The best available science does not allow NMFS to quantify incremental increases in Steller sea lion population responses with the expected increases in prey biomass from foregone fishery harvests.” [BiOp, 362]

Instead, as discussed in Chapter 6, it uses a single-species model which ignores known interspecies interactions to estimate the effects of the RPAs on fisheries biomass, and non-scientific comparisons with changes in growth rates in other areas following the imposition of fishery restrictions to argue that the RPAs will improve sea lion population growth rates sufficiently.

In rejecting the Council’s August 2010 motion, NMFS *implied* that the benefit of an alternative can be measured in terms of either harvest reductions or projected changes in biomass of Atka mackerel, Pacific cod, and all groundfish species, as summarized in the tables on 363 and 369 of the BiOp:

“The remaining features of the Council recommendations were found to not meet the performance standards of the final FMP biop... The primary reasons for not meeting the performance standards is that the Council recommendation would allow amounts of Atka mackerel and Pacific cod harvests in a manner similar to historical practices or at amounts greater than allowed by the performance standards...” [EA/RIR, 2-37, 2-38]

“ . . . The prey field in 543 is expected to improve by approximately 50% under draft revised RPA; in 542 an 8% improvement is expected. Council’s motion led to 3% improvement in prey field in both areas.” (NMFS 2010b)

But harvest reductions are not a measure of benefit to Steller sea lions. Neither are the NMFS’ projected changes in biomass resulting from the harvest reductions. First, as discussed in Chapter 6, the single species models used to project changes in biomass are not a realistic way to project changes in biomass. Secondly, changes in biomass are not a valid indicator of benefit to Steller sea lions. NMFS presents no way to estimate what the response of sea lions might be to

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changes in biomass. The assumption that more biomass necessarily implies more benefit is not justified.

Without a clearer and more defensible definition of benefit, the claim that no lower-impact alternative could achieve the same benefit is not valid.

Similarly, there is no evidence that any economic analysis was undertaken in development of the BiOp RPA to achieve a benefit standard with the least economic impact. At best, presumably an assumption was made that economic impacts would be higher, the greater the extent of restrictions on fishing. But such an assumption is different from systematic comparison of the economic impacts of different kinds of restrictions which might achieve the same level of benefit for Steller sea lion recovery.

Are the RPAs Likely to Minimize Economic and Social Impacts?

It is impossible to know whether the RPA's are likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for Steller sea lion recovery. This is because the BiOp does not provide any way to understand what the benefits of an alternative—either the RPAs or potential alternatives—might be for sea lion recovery. However, we can conclude that *the BiOp and RIR do not demonstrate that the RPA's minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for sea lion recovery.* The BiOp and RIR do not demonstrate what the benefits of the RPAs are for the recovery of Steller sea lions, nor did they provide evidence of seeking to identify alternatives that might have the same level of benefit but lower economic and social impact.

In its August 2010 motion, the North Pacific Fishery Management Council attempted to draft an alternative that might have the same level of benefit for Steller sea lion recovery, but which would have lower economic and social impacts. In drafting an alternative, the fishing industry and the NPFMC had to guess what kinds of lower-impact restrictions NMFS might consider acceptable because the draft BiOp provided no clear indication of what standards (if any) had been set by NMFS for meeting the necessary level of benefit. Most of the suggestions made by industry and the Council were not included in the final BiOp.

More generally, given the lack of evidence in the BiOp for the fisheries-driven nutritional stress hypothesis, there is little evidence that the RPAs will have *any* benefit for Steller sea lion recovery. Thus it is very unlikely that RPAs, which impose “*relatively heavy costs on the on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands,*” would minimize economic and social impacts compared with potential alternatives that would achieve the same benefit for sea lion recovery.

Summary

In general, the analysis described in the Environmental Assessment and Regulatory Impact Review (RIR) of economic impacts of the chosen set of RPAs is reasonably complete, scientifically valid and adequate. It addresses most of the questions it should address

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objectively and reasonably, given the limits of available data and confidentiality restrictions. It supports the conclusion that “...*this action will impose relatively heavy costs on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands.*” More detailed analysis might have strengthened, but would not have changed this fundamental conclusion.

The RIR includes an analysis of the economic benefits of full Steller sea lion recovery. This is not an analysis of the economic benefits attributable to the uncertain effects of the alternatives. The RIR does not provide a cost-benefit analysis of the alternatives.

The BiOp and RIR failed to demonstrate that the RPAs minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for Steller sea lion recovery. Neither document could demonstrate this because neither demonstrated what the benefits of the RPAs would be for sea lion recovery, or demonstrated an effort to identify alternatives that would have the same level of benefit but lower economic and social impact.

8. CONSIDERATION OF PEER AND PUBLIC COMMENTS

Our Terms of Reference asked:

Is there evidence that the relevant peer and public comments concerning economic and scientific issues were considered when developing the BiOp—including comments on the draft BiOp?

Answering this question requires addressing related issues pertaining to interaction with other scientists and industry during the preparation of the BiOp, the time provided for peer and public comment, and the formal peer review process.

Interaction with Other Scientists and Industry in Preparation of the BiOp

A wide range of scientific issues is addressed in the BiOp, and a wide range of scientific studies are referenced—studies based on both published and unpublished data. Understanding these issues is difficult without actively interacting with people who are experienced with the issues and data.

In particular, it is difficult to understand fisheries—and what fisheries data do and do not mean—without actively interacting with people involved in fisheries. It is clear from a review of the public comments on the BiOp that people involved with the fisheries had thoughtful insights to offer about important scientific issues addressed in the BiOp, including in particular how fisheries and the RPAs may affect the availability of prey for Steller Sea lions.

The process for preparing the BiOp did not provide for active interaction with scientists outside the agency or with people in the fishing industry who could have provided useful insights. We believe that the science in the BiOp would have been improved markedly had NMFS actively sought such interaction.

Period for Review of the Draft BiOp and NMFS' Response to Review Comments

A first step in serious consideration of peer and public comment on a scientific document is allowing adequate time for preparation of peer and public comments, and for subsequent consideration of those comments in revising the document.

NOAA Fisheries released the draft BiOp on August 2, 2010, initially providing a period of only 25 days for comment, then subsequently adding an additional week to the period. The draft BiOp and attendant reports and materials ran over 1000 pages. As was noted at the NPFMC meeting in late August, 2010, and by many persons wishing to comment, the time allowed was simply not enough time to cover the required reading, study, and response. We believe that the period of time provided by NMFS for comment on the draft BiOp was insufficient for serious peer and public review.

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NMFS subsequently released the final BiOp on November 24, 2010. We believe that the period of time between the receipt of review comments and NMFS's self-imposed deadline for release of the final document was again insufficient for adequate consideration of review comments or any substantial revision by NMFS of the draft BiOp in response to comments.

Consideration of Relevant Peer and Public Comments

In a letter to North Pacific Fishery Management Council Director Eric Olson dated August 13, 2010, NMFS Alaska Region Administrator Dr. James Balsiger wrote

"The agency will consider Council input, as well as other public comments received on the draft BiOp, to determine whether changes to the draft RPA can be made consistent with the principles and objectives of the draft BiOp . . . We plan to summarize and address comments received on the draft BiOp through August 27, 2010, in a separate document that likely will be appended to the final BiOp."

No such document was appended to the final BiOp or been otherwise provided. Below we review the discussion of and response to public comment that we were able to find in the BiOp and RIR. First we discuss comments on and responses to the finding of jeopardy. Subsequently we discuss comments on and responses to the draft BiOp RPA.

The only discussion we were able to find in the BiOp relating to comments received on the finding of jeopardy and how they were addressed is the following:

"This Biological Opinion was released as a draft document on August 2, 2010. NMFS requested that the public provide comments on the analyses contained in this Biological Opinion and on the conclusions reached. The Council and its Scientific and Statistical Committee and its Advisory Panel convened a special meeting in August 2010 to review the draft Biological Opinion. Over 10,000 comments were submitted to NMFS including extensive scientific reviews of the draft and fairly rigorous critiques of the scientific underpinnings of the conclusions reached. NMFS also requested an internal Agency review of the scientific information contained in the Biological Opinion by a NMFS scientist familiar with Steller sea lions, the North Pacific Ocean ecosystem, and the commercial fisheries prosecuted in this region. NMFS considered the comments and reviews when developing this final Biological Opinion. The comments and reviews pointed to a variety of concerns with the scientific information used to derive the conclusions reached, and NMFS reexamined these issues and made changes in the document to better reflect current scientific consensus. The document was updated, minor errors and omissions were corrected, and the conclusions based on the available data were re-examined. After that re-examination, NMFS continues to conclude that fishery removals of important prey items for Steller sea lions remains a large concern, as described below." [BiOp, 343]

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The absence of any more detailed discussion of comments or how they were addressed makes it difficult to assess the extent to which NMFS considered comments or adopted or rejected suggestions with respect to the finding of jeopardy and the reasons why.

Clearly, some sections of the final BiOp were modified from the draft BiOp. In some cases it appears that modifications were made in response to particular comments. However, it is difficult to assess the extent to which any comments submitted to NMFS resulted in meaningful changes in the final BiOp.

Some additional citations were added to the final BiOp that did not change any of the original conclusions (e.g., Gregr and Trites 2008), while others publications were not cited in any meaningful way (e.g., Merrick *et al.* 1997; Dillingham *et al.* 2006; Trites *et al.* 2010). The list of literature cited thus contains a number of papers with findings that are not discussed or properly considered despite their direct relevance to the conclusions drawn by the BiOp.

Some parts of the draft BiOp were moved to different sections. Some calculations contained in the draft BiOp were also redone and reported in the final BiOp (e.g., forage ratios) based on errors noted by public comments. However, no consideration appears to have been given to the implications of the new calculations, which should have altered the original conclusions. Other incorrect analyses (e.g., the footprint analysis – AFSC 2010) were not changed and continue to be used to support the original conclusions of the draft BiOp.

Much or most of the substantive public comments received by NMFS with respect to the finding of jeopardy appear to have been completely ignored and dismissed, as shown by AFSC (2010) which NMFS continues to use and distribute to show a negative relationship between fisheries and sea lions after being told that the analysis was wrong and scientifically unsound (see SSC 2010). This dismissal of peer review comments suggests that NMFS did not seriously consider the comments they received and were not open to reconsidering whether they had correctly interpreted the available data and drawn the right conclusions.

In the end, it appears that only cosmetic changes were made to the draft BiOp's analysis of jeopardy and that no attempt was made to re-consider any of the original BiOp conclusions in light of the errors and missing information that the public brought to the attention of NMFS. No reply or explanation was issued in response to the considerable comments and criticisms received by NMFS about the errors and shortcomings of the draft and final BiOps.

Discussion in the BiOp and the EA/RIR shows that NMFS did consider and respond to recommendations for changes to the draft BiOp RPAs. Most of the responses were very brief, and most suggestions for change were rejected—but it is clear that comments were considered. The BiOp contains the following references to comments received on the draft BiOp RPA:

The draft Biological Opinion released for public review and comment in August, 2010 contained an RPA based on the performance standards above. During the comment period, NMFS received many comments on the draft RPA which generally fell into one of three categories: support for the RPA in the draft Biological Opinion; support for the motion adopted by the Council at their August,

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2010 special meeting; or suggestions for alternate RPAs to the draft Biological Opinion or Council motion. NMFS reviewed these comments and suggestions, and reanalyzed available data in light of the alternative RPA measures suggested by the public, including the Council's motion. NMFS analyzed alternate suggestions to the RPA in the August 2, 2010 draft Biological Opinion to determine if the alternate measures conformed to the performance standards and would be likely to remove the likelihood that the fisheries would jeopardize the continued existence of the western DPS of Steller sea lions or adversely modify their designated critical habitat. While the resulting RPA is similar to the RPA in the draft Biological Opinion, several adjustments were made to the RPA in response to public comment where NMFS determined adjustments would not unacceptably compromise the conservation value likely to be achieved by the RPA in the draft Biological Opinion. . . . [BiOp, 358]

Because the Pacific cod TAC is established for the entire BSAI and because Pacific cod are migratory, there is concern that harvest historically taken in Area 543 may be concentrated within critical habitat in Area 542 if no additional measures were instituted in this area. . . The RPA in the August 2, 2010 draft Biological Opinion (draft Biological Opinion RPA) would have closed critical habitat within the 0-10 nm zone to directed fishing for Pacific cod for all gear types. . . This aspect of the RPA was modified based on public comment received on the draft Biological Opinion. In their August, 2010 motion (Appendix VII) for Area 542, the Council proposed that no additional restrictions beyond the status-quo regime be placed on vessels under 60' in length using nontrawl gear to fish for Pacific cod. . . [BiOp, 365-366]

“A modification was made to the RPA for trawl gear vessels directed fishing for Pacific cod in Area 542 in consideration of comments received on the August 2, 2010 draft . . . “ [BiOp, 366]

“The RPA in the draft Biological Opinion would have closed 0-20 nm of critical habitat to Atka mackerel trawling in Area 542. The Council's motion for Atka mackerel in Area 542 would have permitted 50% of the TAC to be taken inside critical habitat from 177 E to 178 E longitude and from 180 to 178 W longitude . . . NMFS reviewed the available harvest information and modified the RPA to allow trawling for Atka mackerel within the 10-20 nm zone of critical habitat within a one degree longitude zone in the eastern portion of Area 542. . . [BiOp, 368]

Section 2.3 of the EA/RIR (Alternatives Considered and Not Further Analyzed, pages 2-37 through 2-40) provides a brief discussion of, and responses to the Council's and other public recommendations for changes to RPAs in the draft BiOp. Most of the responses are very brief. For example, this was the response with regard to those portions of the Council recommendations which NMFS did not adopt:

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“The remaining features of the Council recommendations were found to not meet the performance standards of the final FMP biop (NMFS 2010a). The primary reasons for not meeting the performance standards is that the Council recommendation would allow amounts of Atka mackerel and Pacific cod harvests in a manner similar to historical practices or at amounts greater than allowed by the performance standards (NMFS 2010a).” [EA/RIR, 2-37, 2-38]

A NMFS presentation at the October 2010 meeting of the North Pacific Fisheries Management Council summarized public comment on the draft BiOP, NMFS’ response, and NMFS’s conclusions as follows:

“NMFS received ~ 10,600 public comments on Aug. 2nd draft Biop; > 10,000 were form letters in support of the RPA in the draft Biop. NMFS received numerous, substantive comments on scientific, legal, and policy issues pertaining to the draft Biop and EA/RIR; Comments varied as to the science and the stringency of measures required to remove the likelihood of JAM. NMFS received 8 alternate RPA suggestions in addition to the Council’s August 2010 Motion. NMFS equally considered all comments in evaluating proposed adjustments to RPA in the draft Biop. A summary of comments and responses is expected with completion of final Biop. It is not possible to reasonably exclude the likelihood that commercial fisheries in management regions 543 and 542 cause JAM. Where SSL declines are steepest, mitigation needs to be more precautionary. The prey field in 543 is expected to improve by approximately 50% under draft revised RPA; in 542 an 8% improvement is expected. Council’s motion led to 3% improvement in prey field in both areas. [(NMFS 2010b)]

We have not been able to find documentation of the analysis showing that “*Council’s motion led to 3% improvement in prey field in both areas.*”

Formal Scientific Review

Good science actively seeks formal review. No scientist or group of scientists is smart or good enough that their work could not benefit from independent scientific review. Even the best scientists can make mistakes, ranging from simple miscalculations to serious errors in reasoning. Good scientists recognize this. That is one of the reasons why peer review is a standard for publication in scientific journals.

A Bi-Op is not a scientific journal article. But it aspires to be good science, and like all good science could benefit from formal independent peer review.

In his letter to North Pacific Fishery Management Council Director Eric Olson dated August 13, 2010, NMFS Alaska Region Administrator Dr. James Balsiger indicated that such a formal peer review would be undertaken “as soon as is practicable in 2011”:

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“The final BiOp will be scheduled for peer review by the Center for Independent Experts (CIE) as soon as is practicable in 2011. Following completion of this review, NOAA Fisheries will determine how best to proceed in light of CIE’s recommendations. Possible outcomes include reinitiation of formal consultation if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered.”

We are unaware of the initiation of any such formal peer review by NMFS to date. Although we hope that our review will provide useful insights, the agency declined to participate in or assist our review. We believe that the scientific analysis in the BiOp would benefit from NMFS’ active engagement with a formal peer review process.

Consideration of Relevant Peer and Public Comments on the RIR

As with the BiOp, there was inadequate interaction with industry in the preparation of the draft RIR. Of more serious concern, the draft RIR was incomplete at the time it was initially released, making a full process of peer and public comment impossible.

However, in contrast to the BiOp, the final RIR clearly addressed and responded to public comments. [EA/RIR; 10-149 and 10-150] specifically incorporates SSC comments on the draft RIR, and describes how the revised final analysis responded to the comments. It is clear that the economic analysis in the final RIR was improved and strengthened by a good-faith attempt to respond to these and other comments.

Summary

The BiOp was prepared without active interaction with scientists outside the agency or with people in the fishing industry that could have provided useful insights. The period of time provided by NMFS for comment on the draft BiOp was insufficient for serious peer and public review. The period of time between the receipt of review comments and NMFS’s self-imposed deadline for release of the final document was insufficient for adequate consideration of review comments or any substantial revision of the BiOp in response to comments. There is little evidence that comments on the draft BiOp’s finding of jeopardy were considered when developing the final BiOp. There is evidence that comments on the draft BiOp RPAs were considered in developing RPAs for the final BiOp, although responses to these comments were very brief and most suggested changes were rejected. NMFS did not summarize or address comments received on the draft BiOp as had been promised, nor has it scheduled a formal review as promised. In contrast, the RIR clearly addressed and was strengthened by consideration of public and peer comments on the economic analysis.

9. CONCLUSIONS

Our responses to the questions posed in the Terms of Reference for our review of the BiOp (see Appendix A) can be summarized as follows:

1. Do the conclusions in the BiOp regarding the finding of jeopardy and its posited cause (nutritional stress from food competition with fisheries) follow logically from scientific, economic, and social information presented in the BiOp and attendant documents?

The conclusions in the BiOp regarding the finding of jeopardy and its posited cause (nutritional stress from food competition with fisheries) do not follow logically from scientific, economic, and social information presented in the BiOp and attendant documents.

As discussed in Chapter 3, the finding of jeopardy and its posited causes is inconsistent with the lack of evidence for a statistically significant negative relationship between fishing and Steller sea lion populations over the past ten years.

As discussed in Chapter 4, evidence from the BiOp and elsewhere does not support the “fisheries-driven nutritional stress” hypothesis which is the posited cause of jeopardy.

2. Are the conclusions contradicted by any scientific, economic, and social information not presented in the BiOp?

The conclusions are contradicted both by information presented in the BiOp as well as information not presented in the BiOp.

Although we found far more conclusions were contradicted by information in the BiOp, we found that information not in the BiOp also contradicted conclusions in the BiOp. For instance, as discussed in Chapter 3, a statistical study by Sampson (1995) with results consistent with rejecting a negative association between fisheries and sea lions was not found in the BiOp. As discussed in Chapter 4, measurements of uncertainty (CVs) on estimated biomass of Atka mackerel from periodic groundfish surveys (Lowe *et al.* 2010) in the Aleutian Islands not cited or considered in the BiOp compromised conclusions based on assigning biomass to RCAs (rookery cluster area). As discussed in Chapter 5, assuming that a lack of a conclusion relative to the scientific merits of the “*junk food*” hypothesis is a conclusion of no confidence, then that conclusion was contradicted by studies not referenced in the BiOp, such as Merrick *et al.* (1997) and Trites *et al.* (2007a), which linked diversity in diets to rates of change in population abundance of Steller sea lions.

3. Do the conclusions represent the most likely scientific explanation for apparent population dynamics of the WDPS of SSL given the current state of knowledge?

The conclusions cannot be characterized as “the most likely scientific explanation” given the current state of knowledge, because they are not supported by the scientific evidence.

Although considerable research has been undertaken to determine why Steller sea lions declined in the WDPS and why they continue to decline in the central and western Aleutian Islands, there is not yet a consensus among the research community about a “most likely scientific explanation.”

As discussed in Chapters 3 and 4, the data and analyses contained in the BiOp, as well as in publications that are not cited or seriously considered in the BiOp, do not support the conclusions drawn by the BiOp that

“an adverse relationship between Steller sea lions and the commercial fisheries may exist in the western Aleutian Islands sub-region and portions of the central Aleutian Islands sub-region where two specific fisheries, for Atka mackerel and Pacific cod, target important Steller sea lion prey.” [BiOp, 345]

Nor does the scientific record support the conclusion that

“the relative intensity of groundfish fisheries as currently prosecuted within critical habitat is negatively associated with Steller sea lion population response since 2000”. [BiOp, 348]

As discussed in Chapter 5, the scientific record of data and analyses is consistent with the alternative hypotheses that the current decline of Steller sea lions could be driven by a combination of predation on sea lions by killer whales, and the consumption by sea lions of abundant, but low-quality prey species. These alternative hypotheses cannot be rejected.

4. Were alternative scientific explanations to the apparent population dynamics of the WDPS of SSL thoroughly considered, such as explanations involving but not limited to predation, disease, ecosystem/carrying capacity, or emigration?

Two leading alternative scientific explanations for the apparent population dynamics of the WDPS of SSL were not thoroughly considered.

As discussed in Chapter 5, the “environmentally-induced nutritional stress” (“junk food”) hypothesis was not adequately presented or tested. References were incorrectly cited, concepts misunderstood, and authors misquoted. Unlike the discussion of the “fishery-induced nutritional stress” hypothesis, there was no schematic for the environmentally-induced nutritional stress hypothesis, no list of conditions that could be compared with data to judge the merits of the alternative, no decision points, and no lines linking the quality or diversity of diet to sea lion

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abundance. Most importantly, there was no clear discussion or conclusion as to whether this alternative hypothesis was viable.

As discussed in Chapter 5, the “killer whale” hypothesis, was discussed in detail in the BiOp. The BiOp concluded that “. . . there is ample literature to suggest that in some areas, particularly areas of low Steller sea lion abundance (e.g., the central Aleutian Islands), killer whale predation can be an important factor in either causing continued declines or contributing to a lack of a robust recovery.” [BiOp, 173]. This conclusion was not given adequate consideration in developing RPAs. We found no evidence that killer whales were part of the multi-species modeling cited in the BiOp even though they are a known source of significant mortality in sea lions.

5. Do the Reasonable and Prudent Actions (RPA) imposed on the fishery follow logically from the conclusions regarding jeopardy?

Although the Reasonable and Prudent Actions are consistent with the hypothesis underlying the conclusion of jeopardy, modeling results reported in the BiOp suggest they will have little effect on Steller sea lion numbers.

As discussed in Chapter 6, restrictions on the Atka mackerel and Pacific cod fisheries in the western and central Aleutian Islands are a logical consequence of finding of JAM for the federal action. However, multi-species modeling (Aydin 2010) indicates that the RPAs will have little effect on sea lion numbers by restricting fishing for Pacific cod and perhaps little effect from closing Atka mackerel fisheries.

6. Are the RPA’s sufficient to mitigate jeopardy?

The RPAs are not relevant to the recovery of Steller sea lions.

As discussed in Chapter 6, the RPAs are based on the premise that fisheries are inhibiting the recovery of sea lions in the western and central Aleutian Islands, and thus impose restrictions of those fisheries. The statistical and scientific evidence in and outside the BiOp shows something other than fisheries is causing the decline in sea lion numbers. The evidence shows that RPAs based on restricting fisheries are incapable of causing recovery of sea lion populations.

7. Are the RPA’s likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for SSL recovery?

The BiOp and RIR do not demonstrate that the RPAs are likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for Steller sea lion recovery.

As discussed in Chapter 8, the BiOp and RIR do not demonstrate what the benefits of the RPAs are for the recovery of Steller sea lions, nor did they seek to identify alternatives that might have the same level of benefit but lower economic and social impact. Given the lack of evidence in

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the BiOp for the fisheries-driven nutritional stress hypothesis, there is little evidence that the RPAs will have *any* benefit for Steller sea lion recovery. Thus it is very unlikely that RPAs, which impose “*relatively heavy costs on the on the fishing and processing industry that targets Atka mackerel and Pacific cod in the Aleutian Islands,*” would minimize economic and social impacts compared with potential alternatives that would achieve the same benefit for sea lion recovery.

8. Are the RPAs likely to effectively meet recovery goals for the WDPS of SSL?

The RPAs are unlikely to meet recovery goals for the WDPS of Steller sea lions.

As discussed in Chapter 6, the RPAs are based on the premise that fisheries are inhibiting the recovery of sea lions in the western and central Aleutian Islands, and thus impose restrictions on those fisheries. The statistical and scientific evidence in and outside the BiOp shows something other than fisheries is causing the decline in sea lion numbers, and that the RPAs will not affect the progress towards recovery goals.

9. Is the scientific record reported in the BiOp reasonably complete?

The scientific record reported in the BiOp is extensive and cites most of the relevant literature. However, the BiOp does not accurately reflect the scientific evidence in the literature it reports.

The BiOp cites most of the scientific documents pertaining to Steller sea lions and groundfish in Alaska. But simply citing a document and putting it among a long list of literature cited does not mean that the BiOp reflected upon the findings or gave them any serious consideration. A number of studies (*e.g.*, Merrick *et al.* 1997; Dillingham *et al.* 2006; Trites *et al.* 2010) were referenced, but the significance of their findings was never mentioned or discussed in the BiOp. There are also a number of citations cited in the BiOp (*e.g.*, Trites and Rosen 2003; York 2003; Rea *et al.* 2010) that are not contained in the list of literature cited and do not appear to be actual documents; and then there are citations (*e.g.*, AFSC 2010a) that correspond to more than one paper in the list of papers cited. All in all, the BiOp did not meet the basic academic standards in checking the accuracy and completeness of their citations. Thus, the scientific record as reflected by the literature cited and by manner in which the BiOp referenced the published literature contains a number of errors and some significant omissions of factual information that are at odds with the major conclusions of the BiOp.

10. Is there evidence that the relevant peer and public comments concerning economic and scientific issues were considered when developing the BiOp—including comments on the draft BiOp?

There is little evidence that relevant peer and public comments were considered in developing the BiOp, particularly in its analysis of jeopardy.

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As discussed in Chapter 8, no opportunity was provided for peer or public comment on economic and scientific issues prior to release of the draft BiOp. There is little evidence that comments on the draft BiOp's finding of jeopardy were considered when developing the final BiOp. Although some sections of the final BiOp were modified from the draft BiOp, it is difficult to assess the extent to which any comments submitted to NMFS resulted in meaningful changes in the final BiOp's analysis of jeopardy. There is evidence that comments on the draft BiOp RPAs were considered in developing the final BiOp RPAs, although responses to these comments were very brief and most suggested changes were rejected. In contrast, the RIR clearly addressed and was strengthened by consideration of public and peer comments on the economic analysis.

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APPENDICES

A. Terms of Reference for the Review Panel

Independent Scientific Review of the Final Biological Opinion of the Fishery Management Plan for Groundfish Fisheries of the Bering Sea and Aleutian Island Management Areas

4 May, 2011

The Terms of Reference (TOR) for this review of the 2010 Biological Opinion (BiOp) arising from a Section 7 consultation required under the Endangered Species Act (ESA) are:

- a) Four scientists will be impaneled to review the BiOp and produce a report of that review. The panel will consist of two co-chairs, one selected by the Alaska Department of Fish and Game (ADFG) and the other by the Washington Department of Fish and Wildlife (WDFW). The co-chairs will select two other members. All four will be experienced scientists in one or more fields of fisheries management, animal population dynamics, marine mammal biology, and resource economics. None of the four will be federal employees, or have any direct connection with development of this BiOp. Conclusions of the four-member panel will be by consensus. At their discretion the National Marine Fisheries Service (NMFS) and the North Pacific Management Council may each select a member of their staff to serve as a liaison with the panel. The Alaska Department of Fish and Game and the WDFW will arrange administrative support for the panel and will cover costs of meetings and publications.
- b) The panel will focus, but not necessarily limit, their review on the conclusions in the BiOp regarding the Western Distinct Population Segment (WDPS) of Steller sea lions (SSL). The panel will judge and report on how well the BiOp met the following:
 - Do the conclusions in the BiOp regarding the finding of jeopardy and its posited cause (nutritional stress from food competition with fisheries) follow logically from scientific, economic, and social information presented in the BiOp and attendant documents?
 - Are the conclusions contradicted by any scientific, economic, and social information not presented in the BiOp?
 - Do the conclusions represent the most likely scientific explanation for apparent population dynamics of the WDPS of SSL given the current state of knowledge?
 - Were alternative scientific explanations to the apparent population dynamics of the WDPS_of SSL_thoroughly considered, such as explanations involving but not limited to predation, disease, ecosystem/carrying capacity, or emigration?

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- Do the Reasonable and Prudent Actions (RPA) imposed on the fishery follow logically from the conclusions regarding jeopardy?
- Are the RPA's sufficient to mitigate jeopardy, and are they likely to minimize economic and social impacts compared with potential alternatives which would achieve the same benefit for SSL recovery?
- Are the RPAs likely to effectively meet recovery goals for the WDPS of SSL?
- Is the scientific record reported in the BiOp reasonably complete? and
- Is there evidence that the relevant peer and public comments concerning economic and scientific issues were considered when developing the BiOp—including comments on the draft BiOp?

The panel will use their experience, knowledge of the relevant scientific literature, and relevant public comments in their judgments. Knowledge will include, but will not be limited to, recently published scientific papers, recent stock assessments, and recent population surveys. Relevant public comments will include, but will not be limited to, comments submitted by industry, scientists and the North Pacific Management Council through their Science and Statistical Committee concerning the BiOp in general and concerning specific modifications to RPAs. During their deliberations the panel will note any potential investigations that could likely provide new information critical to eliminating or possibly confirming a scientific explanation of the apparent slow recovery of the WDPS of SSL.

- c) The panel will entertain public and scientific comment on issues concerning the BiOp during an open, one-day meeting scheduled for 2 June in Seattle. The ADFG and/or WDFW will arrange and announce the specific time and specific place of the meeting.
- d) The panel will produce a draft report of their findings by 30 June of this year. The ADFG and WDFW will release the draft to the public and relevant agencies for their review and comment. Any forthcoming comments can be sent to the panel through ADFG and WDFW, or presented to the panel during a second one-day meeting on 1 August in Anchorage. Again, ADFG and WDFW will arrange and announce the specific time and specific place for the meeting.
- e) The panel will present a final report to ADFG and WDFW on their review of the BiOp on the fishery management plan for the groundfish fisheries of the Bering Sea and Western Aleutian Islands. The report will have an executive summary based on consensus judgments by the panel on those issues outlined in item b) above. The body of the report will contain explanations for those consensus judgments along with any issues over which the panel did not attain consensus and why. The panel will identify in the report any new research it believes critical to resolving any lack of consensus or disagreement with conclusions in the BiOp. The report will be submitted to ADFG and WDFW by COB 30 September of this year.

B. Biographies for the Review Panel Members

The two Panel co-chairs were chosen by the States of Alaska and Washington:

Dr. David Bernard is the co-chair of the panel representing Alaska. He is a fisheries scientist and biometrician with over 30 years post-graduate experience involving management of commercial and recreational fisheries for salmon and non-salmon species in the Pacific Northwest. His post-graduate work has involved population dynamics and stock assessment resulting in over 75 papers and reports; his graduate research involved modeling predator-prey relationships among fish populations. A former faculty member at Oregon State University and a former employee of the Alaska Department of Fish and Game, Dr. Bernard retired in 2007 as the scientist in charge of the Research and Technical Services Section of the Department. He currently is a member of the Chinook Technical Committee and is a co-chair of the Sentinel Stocks Committee for the Pacific Salmon Commission.

Steven Jeffries, the Washington co-chair, is a Research Scientist and marine mammal specialist for the Washington Department of Fish and Wildlife. He has worked on a variety of Northwest marine mammal issues for over 30 years with a focus on harbor seals, California sea lions, Steller sea lions and sea otters. His research efforts on these species have included studies to address their general biology, distribution, abundance, status, trends, diet, foraging ecology, and contaminant pathways. He is a member of NOAA's Pacific Scientific Review Group and represents the Department in efforts to mitigate regional marine mammal fishery interaction issues.

Two additional Panel members were chosen by the co-chairs.

Dr. Andrew Trites is a Professor and Director of the Marine Mammal Research Unit in the Fisheries Centre at the University of British Columbia. His main area of research is the interaction between marine mammals and fisheries. His research encompasses the ecology, population biology and bioenergetics of seals, sea lions and whales, and involves a combination of field, captive and computer studies. He directs the North Pacific Universities Marine Mammal Research Consortium and holds a BSc from McGill University, and an MSc and a PhD from UBC.

Dr. Gunnar Knapp is a Professor of Economics at the University of Alaska Anchorage Institute of Social and Economic Research, where he has worked since receiving his Ph.D. in Economics from Yale University in 1981. For the past thirty years Dr. Knapp has been continuously engaged in research on fisheries management, seafood markets, and the Alaska economy. Dr. Knapp teaches courses at the University of Alaska Anchorage on fisheries economics and the Alaska economy. He is currently writing a book on "An Introduction to the Economics of Fish."

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